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Gas Journal

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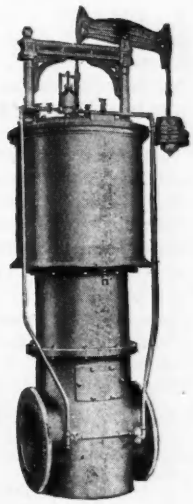

Fig. 29
Pressure-Loaded Station Governor, HAND OR CLOCK CONTROL

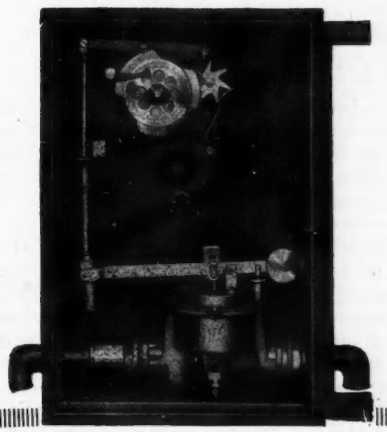

Fig. 49
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GAS JOURNAL, OCT. 27, 1943

VOL. 242 95th YEAR No. 4197

EDITORIAL NOTES

INDUSTRY AND RESEARCH

HARD upon the heels of the pamphlet by Sir Harold Hartley appealing for industrial research on a far wider scale, and the memorandum of the Parliamentary and Scientific Committee on scientific research and its place in the universities after the war, comes a further plea for increased awareness of the part that must be played by industrial research in post-war Britain made in a report issued last Friday by a special Committee of the Federation of British Industries—a report which quite rightly has received much prominence in the national Press. These documents are symptomatic of the growing appreciation of Britain's need to approach future tasks with enlarged facilities for research and for the practical application of the results of this research, and, of course, this concentrated drive is of direct interest to the Gas Industry. The importance of the matter is in fact receiving almost universal assent.

This country has a peculiar gift—originality of mind—and most of the industries owe their origin to British genius. One has only to consider Murdoch and the Gas Industry, Faraday and the development of electricity, or Perkin and the growth of the chemical industry. But one must consider, too, the speed of application of the results of British discovery by other nations, obviously to the commercial disadvantage of this country as an exporting nation. And after the war British industry will require not only to maintain the highest measure of productive efficiency, but to introduce new materials and to develop new products.

We realize that neither money spent nor numbers employed on research are sufficient indication of the worth of research at any given time. Results of the utmost importance have been and are being achieved by individual men or small groups with scantiest resources at their command. Money cannot create a Murdoch, a Faraday, a Perkin, but it can provide facilities for speedy application and development, and obviously it can be a prime factor of encouragement. We must, too, take stock of what other countries are doing. We have said that it is not only the numbers employed in scientific research and the expenditure which is involved which are of ultimate importance; individual aptitude and successful results are of the first importance. One scientific genius may render greater service than a score or a hundred laboratories, no matter how lavishly endowed; and genius or even initiative cannot be easily evoked. At the same time, the more widespread and active the effort made by a nation in this regard, the more likely that genius and initiative will be revealed. And the fact remains that on the expenditure basis we occupy only fourth place among the nations of the world.

SCALE OF EXPENDITURE

THE F.B.I. report discusses whether research and development activities are being carried out on a sufficient scale to enable British industry to take its proper place among the leading industrial nations after the war. The conclusion is reached that the amount spent on research by individual firms and the research associations, though in some instances substantial, in total represents an insignificant percentage of the value of industrial production. "We are of opinion," the report states, "that if 1% of the value of our industrial production were expended on research and development, involving the provision of personnel and facilities, the resulting increased productive efficiency and employment capacity would yield an annual return of many times such expenditure."

The Committee is convinced that, while the research associations are playing a valuable part (their expenditure on research, it is estimated, will this year amount to £850,000), subscriptions to them show that industry does not fully appreciate the benefits that can be derived from collective research. It presses for the strengthening of the research association movement, putting forward the recommendation that financial provision should be made from public funds to enable the D.S.I.R. to increase and continue indefinitely financial support to research associations and similar organizations as a permanent feature of the national economy, following this by the concrete suggestion that the Government should allocate to the Department an annual sum of at least £1,000,000 for the maintenance and expansion of its activities.

LUCID EXPOSITION

CONSIDERATION is then given to the relations of research associations to subscribing members, and we welcome the insistence that the director of research and his staff shall be capable of setting out the results of research in a readily assimilable form. Obviously this requires the closest association between the scientific personnel of the research association and the technical management of the individual members. For many years we have emphasized the real need for what we may term "lucid exposition." It is useless to publish scientific reports in a language which the technical management cannot assimilate, and which does not point clearly and directly to methods of applying the conclusions of the reports to the technical processes of the industry for which they are made. And we suggest the desirability in our own Research Board of maintaining a liaison department specially charged with advising on how the results of the Board's investigations can best be applied to the circumstances of individual gas undertakings. The success of this would, we would add, depend upon the degree of co-operation forthcoming from the undertakings themselves; fortunately we have evidence of the desire of undertakings to co-operate in this way.

Naturally expansion of industrial research and development postulates the need for providing the necessary trained personnel for conducting it, and this implies greater recruitment from the universities and technical colleges. Touching on this the report wisely adds that little benefit will be derived from increasing the numbers of those engaged in research if more trained minds are not employed in other branches of industry. The general scientific outlook of industry must be raised if the understanding and application of new scientific inventions, discoveries, and developments are to be increased; and we like the emphasis laid in the report that research staff should be given a definite standing in the hierarchy of the organization. The time has surely gone by when members of the research staff were kept remote from other branches of the undertaking, and were regarded as "engaged on some obscure and ancillary activity outside the mainstream of the undertaking's interests, to be called upon only when things went wrong."

A RESEARCH BUREAU

IT is not, then, that the F.B.I. Committee is not satisfied with the general scheme of organization by which industrial research and development are at present conducted in this country and with the various types of organization which exist. But it is clear enough from its recommendations that it is not satisfied with the scale on which research is prosecuted and the degree to which the existing machinery is utilized; and it also insists that pure science should receive much greater support from industry and the State. In brief, the report's purpose is

to stimulate a greater provision of resources in money and personnel for all types of research than is at present available. We have sketched the report in outline only, but we would mention one further recommendation—that a Bureau of Industrial Research should be established in the immediate future, which should be national in scope and, though financially supported by those principally concerned, such as research associations, independent scientific bodies, Government research establishments, universities, and so on, should be entirely objective in its activities. This Bureau, it is suggested, might undertake educational publicity on research, and help to bring together research workers in similar and related fields.

CO-OPERATION

THE F.B.I. report comes at a time when the research associations concerned with the fuel industries are seeking to arrive at a more fruitful measure of co-operation through the Standing Consultative Conference on fuel research which has been organized by the D.S.I.R. We referred to this co-ordinating committee in the "JOURNAL" of June 30 last, and it has now started work in its endeavour to avoid overlapping, foster co-operation, and channel effort in those directions likely to be most productive. There is nothing dictatorial about the committee, which constitutes a practical means by which the associations concerned—the British Coal Utilization Research Association, the British Electrical and Allied Industries Research Association, the British Iron and Steel Industrial Research Council, the British Refractories Research Association, the Fuel Research Board, the Gas Research Board, and the Hard Coke Research Association—can get together, sift out their appropriate problems, and obtain the best value from their work. Granted tolerance, goodwill, and understanding, good results from this collaboration would appear to be assured. The field covered by the associations we have listed is a vast one, but there is no room for any competitive element between one association and another—an element which we trust will not rear its head in the associations' composite work. There is ample work, without undesirable overlapping, for each association to tackle. And as a first step it would appear desirable to establish a central abstracting and translating service which can be called upon as occasion arises by any of the associations—a general "information bureau" on scientific research and literature concerned with fuel. Such a service—which ought not to be of any makeshift nature, but should be carefully planned—would not obviate the need for the individual associations to set up intelligence sections on the lines indicated in the "JOURNAL" of June 30 last in connexion with the Gas Research Board.

Personal

G.L.C. Appointments

Mr. N. WILLSMER, who for the past six years has been Station Engineer at the Nine Elms Works of the Gas Light and Coke Company, has been appointed Deputy Chief Engineer to the Company in succession to Mr. J. S. THORMAN. Mr. Thorman is retiring shortly, but the Company will continue for the time being to have the benefit of his services in a consultative capacity.

Mr. Willsmer began his career with the Ilford Gas Company in 1905. He was appointed Works Chemist at the Brentford Station of the Brentford Gas Company in 1909. On the amalgamation of the Brentford and Staines Companies he became Engineer of the Staines Works. In 1924 he was appointed Engineer of the Harrow Works, and, shortly after the amalgamation of the Brentford and Gas Light and Coke Companies, was transferred to Fulham Works as Deputy Station Engineer. In 1932 he became Engineer of the Bow Common Station, and three years later was promoted Engineer at Bromley. From Bromley he went to Nine Elms Works, where he remained until his present appointment.

Mr. Thorman entered the service of the late West Ham Company 47 years ago as a pupil of his father, who was Engineer of that Company; his grandfather had been the first Engineer of the same Company. After serving with the Gas Light and Coke Company at Stratford, Beckton, Bow Common, Southall, and Fulham, he was in 1941 appointed Deputy Chief Engineer. For some years he was Chairman and Chief Examiner in Gas Engineering of The Institution of Gas Engineers' Education Scheme. He was awarded the Institution Gold Medal for 1931 for his Paper on "Intermittent Vertical Chambers and Coal and Coke Handling Plant at Southall."

Mr. W. E. DAVIES, previously Station Engineer at Kensal Green Works, has been appointed Station Engineer at Nine Elms; Mr. J. A. HEPWORTH, Station Engineer at Stratford, Station Engineer at Kensal Green; Mr. J. BURNS, Acting Deputy Station Engineer at Bromley, Station, Engineer at Stratford; Mr. H. W. MOYS, Deputy Station Engineer at Bromley Works.

Mr. S. M. THOMSON hasb een appointed Acting Assistant Distributing Engineer.

* * *

In consequence of his appointment as Director-General of the B.B.C., Mr. R. W. FOOT has resigned his position as a Director of South-Eastern Gas Corporation, Ltd., and its Associated Companies. In his place the Directors have elected Mr. A. E. SYLVESTER, Managing Director of the Gas Light and Coke Company.

* * *

Mr. H. E. BLOOR, who recently relinquished the Secretaryship of the York Gas Company, has resigned from the positions of Engineer and Manager in order to devote himself to his representative work for the Company and directorial activities. He has now been appointed a Consulting Director to represent the Company on national and other organizations of the Gas Industry. Mr. Bloor is a Director of the West Yorkshire Gas Distribution Company, the Hemsworth and United Kingdom Coke Oven Company, and other companies, and is Chairman of the Yorkshire Joint Tar Board and the Easingwold Gas Company.

* * *

Mr. J. POWLING, B.Sc., A.R.C.S., has been appointed to the Gas Light & Coke Company's Gas Research Fellowship at the Imperial College of Science and Technology for the year ending Sept. 30, 1944.

Obituary

Mr. F. J. ANGELL, for many years a Director of Humphreys and Glasgow, Ltd., died on Oct. 25 after a short illness.

Letter to the Editor

Cooking by "Neat" Gas

DEAR SIR,—I am very sorry I was not able to be present at the Southern Association Meeting on Oct. 6, to hear Mr. Dean Chandler's most interesting Paper on the use of "neat" gas for cooking. Reading Mr. Chandler's paper in your issue of Oct. 13 brings back very clearly to my memory the fact that my grandfather, J. O. N. Rutter (who was Engineer of the old Brighton Gas Company from 1835 to 1885), had in use in his kitchen at Black Rock a "neat" gas oven, which was in daily use for cooking the joint for dinner. This was in the 1870's when, as a boy, I used to stop at Black Rock for my holidays. To the best of my recollection the oven was circular or elliptical in shape, with a ring of batswing burners spaced about 3 or 4 in. apart. I believe the oven was constructed on the works and was an efficient piece of apparatus.

Yours faithfully,
C. H. RUTTER.

Sandhill,
Crawley Down, Sussex.
Oct. 16, 1943.

Diary

Oct. 29.—Manchester District Association of Gas Engineers: Midland Hotel, Manchester, 2 p.m.

Oct. 30.—Yorkshire Junior Gas Association: General Meeting, Bradford, 2.30 p.m.

Nov. 5.—National Smoke Abatement Society: General Meeting and Conference, Caxton Hall, S.W. 1, 10 a.m.

Nov. 8.—National Federation of Gas Coke Associations: General Committee (Special Meeting), Gas Industry House, 2.45 p.m.

Nov. 9.—National Federation of Gas Coke Associations: General Committee, Gas Industry House, 9.30 a.m.

Nov. 15.—London and Counties Coke Association: Finance Committee, 11 a.m.; Executive Committee, 11.30 a.m.; Central Committee, 1.30 p.m., Gas Industry House.

Nov. 17.—Eastern Counties Gas Engineers' and Managers' Association: Gas Industry House.

Nov. 26.—Southern Association of Gas Engineers and Managers (Eastern Section), Paper by Dr. Weston and Dr. Haffner, entitled "New Evidence in regard to the Mechanism of Carbonization in Continuous Vertical Retorts," Gas Industry House.

Ministry of Fuel and Power

The Minister of Fuel and Power announces that he has appointed Mr. H. H. Holmes, at present the Regional Controller for the Eastern Region of his Ministry, to be Director of Services at Headquarters. This post, which was created in pursuance of the Government White Paper on Coal (Cmd. 6364), has recently become vacant owing to the transfer of Mr. J. Innes, C.B., to be Director of Opencast Coal in the Ministry of Fuel and Power.

THE CHEMICAL INDUSTRY

An Address on the future of the chemical industry was given by Lord McGowan (Imperial Chemical Industries, Ltd.) at a joint meeting of the Chemical Engineering Group of the Institution of Chemical Engineers and the London Section of the Society of Chemical Industry on Oct. 12, at the Institution of Mechanical Engineers. Remarking that he did not suggest that the war was as good as over, he suggested that there was the greatest necessity for a large increase in our research effort. The total research effort in Great Britain was shared between the universities, industry and the Government, but the present was an opportune time to consider the closer definition of the functions of these three parties, if wasteful overlapping was to be avoided and if the effort made was to achieve the best results. The main function of the universities was to train and turn out for the benefit of the community the best type of research worker. All other considerations should be subservient to this end. The essential aim should consist of the study of fundamental problems aiming at an extension of our knowledge of the laws of nature. At the same time, it would be a great advantage to both sides if the universities and industry maintained closer personal contact, and means by which this closer association of industrial and university workers could be achieved should not be difficult to find.

Lord McGowan went on to say that outside the scope of fundamental and industrial research was the vast body of work which must be done under Government auspices, from which the community as a whole benefited, but which were too far from being straightforward commercial propositions to be undertaken by any independent concern or even by a Research Association. The most outstanding example of what he had in mind was coal. The coal picture here to-day was anything but satisfactory, for we were making deep inroads into our deposits of easily won and high quality coal while mining costs were still rising in a spectacular fashion. It was worth while remembering two unpalatable facts. One was that during the past six years, the cost of winning coal in this country had risen by no less than 70%, and by all the current indications still further increases must be expected. The second was that pit prices of coal in the U.S.A. were lower than corresponding prices in this country by an amount equivalent to about 10s. per ton—*i.e.*, U.S.A. prices were cheaper than ours by an amount which was little less than our total pre-war cost of coal at the pit. Whether or not the chemical industry and, indeed, the whole of British industry, could stand such an immense handicap in the race for production, even in the home market, might be a matter for argument, but there could be no doubt of the danger it represented to our export trade.

The present decline in the total output of coal was a further cause for uneasiness, and therefore it was urgently necessary that every ton of coal consumed in this country should be won at the lowest possible cost and utilized to the very best advantage. This could only be achieved if a comprehensive programme of research was put in hand, and prosecuted with the utmost vigour. He recognized the valuable work done by the Fuel Research Station, and noted the far-reaching proposals for research to be undertaken by the Coal Utilization Research Association, but having regard to the complexity of the problems to be solved and the importance of the issues to industry, it might well be that a large scheme might prove to be necessary. The responsibility for organizing and co-ordinating a programme of this magnitude was clearly the Government's.

A further point of much importance to industry concerned patents and their exploitation. There appeared to be a feeling that because companies and individuals could at present obtain exclusive licences for a particular process, they were in a position either to sell the product at a higher price, or suppress it altogether if it threatened processes in which they were already interested. It had been suggested that the system of exclusive licences should be abolished, and superseded by one of non-exclusive licences obtainable as a right by all wishing to secure them. That proposal had been made with the worthy aim of assisting the national effort, but he was sure its adoption would have precisely the opposite effect. The grant of non-exclusive licences would lead direct to unrestricted competition and to manufacture in small units and at high costs. It would also lead to a great increase in the operation of inventions as secret processes, with the most unfortunate effect. In general, said Lord McGowan, there was an insufficient realization of the fact that matters such as he had discussed had been foreseen and remedies for abuses had been provided on an ample scale in the Patents Act itself. Should any abuses which had not been foreseen make their appearance—and he was not aware of any—the remedy was to obtain an extension of the existing safeguards and not seek to effect any revolutionary changes, which, in his view, would do far more harm than good.

Another aspect of the chemical industry which should receive more careful consideration in the future was what he called, for want of a better name, "development"—*viz.*, the conversion of research results into commercial processes. There must be collaboration with potential consumers in order to assess the merits of the product and to determine the most advantageous form in which to produce it. Another important duty of a development organization was to decide at what point any given research was ready for commercial exploitation. Development staffs must follow the progress of the research, and decide the point at which the first steps should be taken towards commercial exploitation. Research directed towards the final perfection of the process would, of course, continue, but it would be carried on at the same time as development. Finally, markets must be assessed in order that the size of the first commercial scale plant should be appropriate. He wondered if, in the past, we had not been too narrow in our outlook as regards the manufacture of new products or in starting a new part of industry. He asked for more of a spirit of adventure, and that those who could afford it—and this might apply more to large manufacturing units or industrial corporations—should take more of a chance than they had done in the past. Let us forget the slogan "Safety first." Britain stood where it did to-day through the courage shown by our predecessors—an example we should follow. Research and development, although distinct in their functions, were so closely interlocked that it was frequently impossible to tell where one ended and the other began, and there was, therefore, all the more necessity for the two organizations to work together as a team. In other words, those engaged in development must work in the closest possible collaboration with the research personnel.

And what about "seniors" in industry? If, said Lord McGowan, senior officials were more assiduous in their support of societies, then the younger men would tend to follow their example. Technical and kindred societies had justifiable complaint against the larger chemical concerns—that the representative officials did not seem to be doing their share of public work. His own view was that if the problem of securing the membership and attendance at meetings of the officials of the larger companies could be solved—as he sincerely hoped it would—the latter difficulty would disappear.

Another and wider aspect of this matter was that it was rare to find scientific men taking a prominent part in the guidance of local public affairs. This was a most unfortunate circumstance, because the ranks of scientists included men of the highest integrity and intellectual attainment. Industrialists should encourage their scientific staff to take a more active interest in the life of the community outside their own particular sphere.

Science and the Coal Industry

A Meeting of the North-Eastern Section of the Institute of Fuel was held in Newcastle-on-Tyne on Oct. 18. The chair was taken by Mr. S. E. D. Wilson, who was supported by the President of the Institute, Dr. E. W. Smith, C.B.E., and the Secretary, Mr. P. C. Pope. Mr. J. G. Bennett, Director of the British Coal Utilization Research Association, addressed the meeting on "Science and the Coal Industry," on the work of which he said: "There are three partners to the enterprise of bringing a scientific discovery into general use. The first is the scientist who discovers the new piece of knowledge. The second is the engineer, who combines new knowledge with existing knowledge and experience to make something which will work. Thirdly, there is the industrialist whose judgment, whose powers of organization and management provide the engineer with the conditions required to convert the enterprise into what is called a 'going concern.'

"It had become almost a parrot cry to say that the days of using coal merely as a fuel have passed, and we must regard it in future as a raw material, but very few people have really attempted to understand what this implies. He would venture to predict that there is no major raw material produced from the earth's crust which is likely to see such an amazing transformation in the manner of its use during the next 20 years as coal. This will come about by the application of the scientific method, both to the nature of coal viewed as a chemical compound and also to the utilization of coal as a source of energy, and to the co-ordinated activities of scientists, engineers, and industrialists."

The Directors of Associated Gas and Water Undertakings, Ltd., have declared an interim dividend on the Ordinary Stock of 2½% actual, less tax, and an interim dividend on the Deferred Stock of 3% actual, less tax, payable Nov. 30, on account of the year ending March 31, 1944.

The Next Meeting of the Yorkshire Junior Gas Association will be held at Bradford on Saturday, Oct. 30, at 2.30 p.m., when an inspection will be made of the purging machine, with an explanatory talk by Mr. G. Griffiths.

A Meeting of the Manchester District Association of Gas Engineers will be held at the Midland Hotel, Manchester, on Oct. 29 at 2 p.m., when a Paper will be given by Mr. James Carr, M.B.E., M.C., of Stretford, entitled "Ten Post-War Thoughts."

The fact that goods made of raw materials in short supply owing to war conditions are advertised in the "Journal" should not be taken as an indication that they are necessarily available for export.

SOME EFFECTS OF WAR ON THE ECONOMICS OF GAS MANUFACTURE AND SUPPLY*

By T. A. TOMES,

Deputy Engineer and Manager, Stourbridge Gas Department

As a natural consequence of the outbreak of hostilities the Gas Industry has been called upon to meet rising costs in many directions, compelling it to increase the price of gas to the consumer, who, even if he has little option in these times, will certainly choose when the opportunity arises the fuel which is cheapest and best suited to his particular purpose. We can always convince him of the excellence of our product, but how will its cost compare with competitive fuels?

Most keenly felt of all have been increases in the cost of coal, fuel, labour, and maintenance, and it is the object of this Paper to examine the effect of war on those items of plant most affected by these. It is realized that all these items are still variables, yet it is important that we should appreciate the trend of our economic position so that we may be able to strengthen it wherever possible, in order to maintain the cost per therm at a minimum.

It is proposed to examine the economics of the following items of plant:

1. Carbonization (continuous vertical and horizontal retorts).
2. Water gas—blue and carburetted.
3. Benzole recovery.
4. High pressure gas distribution.

On the works side, items 1, 2, and 3 are obvious choices, involving, as they do, the utilization of coal or its chief residuals; but detailed examination of such works plant as condensers, tar extractors, Livesey and scrubber washers may be ignored, since even to-day the cost of water to the average works is still low, while labour and maintenance costs on these items are very small. On the district, high-pressure gas increases in importance as our post-war plans develop, and merits examination as the most important item on our distribution side.

Results were obtained by the writer from two undertakings which he has been privileged to serve, and express in all cases normal working results, which are the figures on which we should base our views, not on test results as is so often done. All plant is typical of that to be found on any works of approximately 700 million cu.ft. per annum.

Carbonization in Continuous Verticals

On any setting of continuous vertical retorts there are a number of fundamental factors affecting the make per ton: Correct temperatures, high steaming efficiency, correct manual attention to retorts and producers, correct back-pressure conditions at retort offtake, size and class of coal, calorific value of gas made, throughput. When the setting is called upon to carbonize a certain class of coal, so as to produce a reasonably constant calorific value of gas, and is supervised by skilled operators, then the influence of throughput becomes of paramount importance. It is proposed, therefore, to examine the economics of carbonization in continuous vertical retorts from this angle.

Results were obtained from a bench of 30 Woodall-Duckham upwardly-heated continuous vertical retorts, set in 5 beds of 6 retorts, size 62 in. by 10 in. by 25 ft., with a nominal throughput of 6.35 tons per diem. These were heated by 5 battery type breeze-burning producers. Two waste-heat boilers were installed, one being standby. A lip type G.B. conveyor encircled the bed lengthwise, and aided by three conveyors and an elevator handled all coal used and coke made on the job. The plant was installed in 1936, and was capable of handling the winter load with only 75% of the retorts at work. The period under consideration dates from the time when the plant was "settled down" beginning October, 1936, to September, 1937. There was no benzole plant installed at this time, and the calorific value of gas supplied was 450 B.Th.U. per cu.ft.

All the coal carbonized was Derbyshire; there was no blending plant, coal being carbonized as received, 85% of which was washed and 15% screened.

Costs

When estimating the net cost per therm it is necessary to take into consideration the following factors—on the debit side, coal cost, coke to producers, capital charges, and labour, and on the credit side, gross coke, tar, and any surplus steam which the plant may supply for other works purposes. The net cost of coal then becomes the cost of the coal, less the net value of the residuals, or, coal cost plus coke to producers, minus gross coke, tar, and surplus steam. The period 1936/1937 has throughout the Paper been taken as the typical pre-war "Basic Year," to provide us with a basis for comparison. The following assumptions were made for this period:

Coal—21s. per ton.

Coke—25s. per ton as discharged (which allows about 1s. 6d. per ton screening below merchant rate).

Coke as discharged contained approximately 7% dust. The same prices were obtained for all sizes down to ⅜ in., below which it was possible to obtain only one-fifth of this price, so that value of coke as discharged = 93% at 25s. + 7% at 5s. = 23s. 7½d. per ton. Coke to external producers contained approximately 20% dust, being worth therefore 80% at 25s. + 20% at 5s. = 21s. per ton.

Tar—2½d. per gallon.

The capital cost of the setting as purchased in 1936, including foundation, two waste heat boilers, coal and coke handling plant in the retort house, but omitting retort house building, was £50,159. The capital charges with which it is necessary to debit the plant must assume a figure sufficient to maintain it in good running order throughout its estimated life, and fully repay any debt incurred by its purchase at the end of it. A total figure of 13½% was considered adequate for this purpose, being based on a life of 15 years, and was made up as follows: Interest payable on capital borrowed 3%, sinking fund 5½%, and maintenance 5%. For calculation purposes the plant capacity was taken at 30 retorts, with 260 working days per annum (which allows for major repairs to the setting every three years or so).

Wages include the usual three shifts of eight hours, consisting of a charge hand, top man, two bottom men, telpher man, and top man mechanic (looks after waste heat boiler, sprays and elevators, &c), plus loco driver, shunter, two coal men, flue cleaners, and an allowance for technical supervision. Weekly wage bill was £97 1s. 7d., which over the period under consideration amounted to 211.81d. per retort per working day.

Surplus steam—18d. per 1000 lb.

Table I summarizes the 1937 balance-sheet.

TABLE I.—62-IN. UP-HEATED VECTICAL RETORTS: SUMMARY OF YIELDS AND COSTS (1937).

Data.—Coal, 21s. per ton. Coke, 25s. per ton to screens. Coke to producers, 21s. per ton. Coke *ex* Retort House, 23s. 7½d. per ton. Tar, 2½d. per gallon. Capital charge, 13½%.

Throughput.					
Tons/day	6.7	6.5	6.35	6.1	5.8
Tons/1 in. major axis/day	0.108	0.103	0.102	0.098	0.094
% above or below nominal	+5.51	+2.36	nominal	−3.94	−8.66
YIELDS.					
Gas.					
Therms/ton	79.4	80.8	81.9	84.0	87.2
Therms/1 in. major axis/day	8.58	8.47	8.39	8.26	8.16
Therms/day/retort	532.0	525.2	520.1	512.4	505.7
Coke.					
Gross cwt./ton	12.0	12.0	12.0	12.0	12.0
„ lb./therm	16.93	16.63	16.41	16.00	15.41
Available cwt./ton	9.36	9.23	9.16	9.02	8.86
„ lb./therm	13.21	12.80	12.53	12.03	11.38
Coke to producers.					
Lb./100 lb. coal	13.2	13.8	14.2	14.9	15.7
Lb./therm	3.724	3.825	3.884	3.973	4.033
Tar.					
Gall./ton	17.5	17.5	17.5	17.5	17.5
Gall./therm	0.220	0.216	0.214	0.208	0.201
Surplus steam (from waste heat).					
Lb./therm	6.54	7.03	7.34	7.82	8.25
COSTS—ALL IN PENCE PER THERM.					
Debit.					
Coal cost	3.174	3.119	3.077	3.000	2.890
Capital charge	0.391	0.396	0.400	0.406	0.412
Labour charge	0.398	0.403	0.407	0.413	0.419
Coke to producers	0.419	0.430	0.437	0.447	0.454
Total	4.382	4.348	4.321	4.266	4.175
Less value of—					
Credit.					
Tar	0.551	0.542	0.534	0.521	0.502
Gross Coke	2.140	2.103	2.074	2.022	1.948
Surplus steam	0.118	0.127	0.132	0.141	0.149
Total	2.809	2.772	2.740	2.684	2.599
Net cost per therm	1.573	1.576	1.581	1.582	1.576
Net cost of coal	0.784	0.777	0.774	0.763	0.745

Effect of War

In Table II basic results have been altered to suit prevailing conditions in June, 1943. Coal has become 33s. 4d. per ton and coke 46s. per ton as discharged (merchant rate becomes 48s., which allows 2s. per ton for screening, &c.), labour has risen by 33½%, tar is 3½d. per gallon, and surplus steam 22d. per 1,000 lb. Capital charges become 16½%, on the assumption that interest and sinking fund charges remain at 8½%, but cost of maintenance rises by 60% (*i.e.*, 5% to 8%). This

* From a Paper to the Midland Junior Gas Association.

figure was obtained by considering primarily the increases in makers' prices for the most important items, which were found to lie between 50% and 60%, and secondly labour required for this maintenance, which, due to reduced staff, has meant that many jobs previously done day work now entail overtime, payable at, say, time and a half on a 33⅓% increase, which is equivalent to approximately double 1937 rate. Thus 60% is considered a fair increase.

TABLE II.

Coal, 33s. 4d. Coke, 46s. to screens. Coke to producers, 38s. 7½d., as discharged, 43s. 5½d. Capital charge at 16½%. Labour plus 33⅓%. Steam, 1s. 10d. per 1,000 lb. Tar, 3½d. per gallon.

Throughput.					
Tons/day	6.7	6.5	6.35	6.1	5.8
COST—ALL IN PENCE PER THERM.					
Net cost per therm	2.020	2.035	2.048	2.061	2.065
Capital and labour	1.009	1.021	1.032	1.047	1.062
Net cost of coal ...	1.011	1.014	1.016	1.014	1.003

TABLE III.

Coal, 38s. Coke, 44s. to screens. Coke to producers, 36s. 11½d., as discharged 41s. 6½d. Capital charge, 16½%. Labour plus 33⅓%. Steam, 1s. 10d. per 1,000 lb. Tar, 3½d. per gallon.

Throughput.					
Tons per day ...	6.7	6.5	6.35	6.1	5.8
Net cost per therm	2.863	2.863	2.862	2.854	2.827
Net cost of coal ...	1.854	1.842	1.830	1.807	1.765

Unfortunately, however, due to the cost of carriage and the vagaries of the coke markets, it is seldom found that any two works have the same coal/coke price ratio, even if they carbonize the same coal. For comparison purposes therefore results have been calculated in Table III, using the values of coal and coke obtained at my present works, while Table IV assumes these values at 38s. each.

TABLE IV.

Coal, 38s. Coke, 38s. as sold. Coke as discharged, 35s. 10½d. Coke to producers, 31s. 11d.

Throughput.			
Tons/day	6.7	6.35	5.8
COST—ALL IN PENCE PER THERM.			
Net cost per therm	3.277	3.255	3.186
Net cost of coal	2.268	2.223	2.124

Relative Importance of Items Forming Balance-Sheet

Coal cost is naturally of most importance, forming between 70% and 75% of the total debit cost, depending on its value. At nominal throughput a rise in price of coal of 3s. 4d. per ton is approximately equal to an increased cost per therm of 0.5d.

Capital charges are in all cases but one less than 0.5d. per therm, constituting the smallest item on the debit side, this pointing to the obvious—that if increased capital outlay gives higher plant efficiency, then it is money well spent.

Labour costs are also in the region of ½d. An extra man on the job at 75s. per week with 22 retorts at work=0.011d. per therm—a negligible amount if plant performance is improved. On the other hand, increased capital outlay and labour costs, if no improvement is shown, represent a constant unnecessary handicap to a low cost per therm, and one which in the former case cannot be remedied until the end of the estimated plant life.

Coke to producers is of more importance than is generally appreciated, but is offset partly by heat recoverable as surplus steam. This figure may be kept at a minimum by correct design of, and manual attention to, producers, avoidance of "idle retorts" under fire, use of, as far as possible, a low-grade fuel, adequate insulation of setting against heat loss, and by maintaining the evaporative efficiency of the waste-heat boiler. No matter what throughput is decided upon as being most economic, it is vital to work the plant at maximum capacity and avoid "idlers." The high cost of maintaining a retort ready for work rapidly destroys any advantage which may otherwise be gained.

Tar receipts are sufficient to clear off capital charges and contribute almost half towards labour cost. 1d. per gallon on tar=about 0.21d. per therm reduction.

Coke receipts represent the maximum contribution towards a low cost per therm. Coke available refers to that available *ex* retort house, which must be reduced by amount used on works to obtain that which is available for sale. Full credit has been given to the plant for the value of coke as it leaves the retort house, but its ultimate value may be considerably reduced if excessive breeze production results from poor handling or preparation, plant, or stocking.

Reference to pre-war costs shows that for all practical purposes the final cost per therm is the same at all throughputs, the difference between the maximum and minimum being only 0.009d. per therm, any slight advantage lying with the highest throughout, while the maximum cost was obtained at a throughput of 6.1 tons.

On examination of Table II we see primarily that the net cost per therm has increased by some 30% and the net cost of coal by 31%, and that the cheapest therm is made at the highest throughput, rising gradually to a maximum at the lowest, with a difference of 0.045d. between them. In Table III, where only the coal/coke ratio is altered, the net cost per therm has risen by 81%, and the net cost of coal by 136%, while the position with regard to the most economic throughput is completely reversed, the maximum cost being now at the highest throughput, falling to a minimum at the lowest, with a difference of 0.036d.

When value of coal and coke are equal (at 38s., Table IV), this again increases the cost per therm and increases the margin in favour of lowest throughput over highest to 0.091d. It is to be noted that the cheapest net cost of coal does not necessarily accompany the cheapest therm (Tables II and III), owing to the effect of the thermal output per diem on capital and labour costs.

It is obvious, therefore, that the economics of carbonization are governed by the current values of coal and coke, and it is possible to summarize the position thus:

1. Ruling factors in the economics of throughput and carbonization generally are the current values of coal and coke, and, to a lesser degree, tar, since its price is more stable. Any increase in coal cost raises the cost per therm, while increases in coke and tar revenue reduce it, and *vice versa*.

2. The more coke value rises above that of coal, the more do conditions tend to favour the use of high throughputs in view of the greater amount of coke available.

3. The lower the cost of coal with a steady coke value, the less important does gaseous thermal yield become, and high throughputs are at a greater advantage.

4. Similarly, the gaseous yield becomes of greater importance as the receipts for residuals are reduced relative to coal cost, and low throughputs are then more economical.

5. Any increase in labour cost or capital charges is against lower throughputs owing to the reduced thermal output per retort per diem.

6. An increase in tar value favours higher throughputs, having a greater effect due to the decreased thermal yield.

7. Choice of throughput must ultimately depend on the capacity of the plant in question, gasholder storage capacity, and the nature of the load—*e.g.*, the average 700 millions works is seldom in that happy position when it can dictate its own throughput from one week-end to the other, particularly in industrial areas, where a heavy load is usually experienced throughout the week with a slack week-end. It will usually be found that under such conditions it pays to use a high throughput during the week, and sacrifice the extra therms per ton as that it may be reduced to a minimum over the week-end, so as to avoid, as far as possible, week-end "idlers," with their high fuel consumption. Each works must be guided by its own load, but knowledge of the effect of throughput does enable the undertaking to take full advantage of the flexibility of the plant, so as to obtain maximum economic efficiency.

8. These results refer to Derbyshire coals, which are very amenable to steaming. Coals from other fields will give different results, which can only be determined by practical experience.

Horizontal Retorts

When carbonizing Derbyshire coal similar to that in the vertical retorts, typical results as given in Table V were obtained from a setting consisting of seven beds of tens, Ω section, 18 in. by 24 in. by 20 ft. long, fitted with hydraulic mains, double ascension pipes, and a bell type retort house governor. The producers were regenerative, and no waste heat boiler was in use.

TABLE V.—HORIZONTAL RETORTS.

Size: 18 in. by 24 in. by 20 ft. (Ω Section).
Charges: 14 cwt. 12 hours.

Yields.

Gas: 68 therms of 520 to 525 B.Th.U. cu.ft. (corrected to 60° and 30 in. Hg.).
Coke: Gross 13 cwt./ton containing 2% dust.
To producers: 12½ lb. per 100 lb. of coal carbonized.
Tar: 9½ gall./ton.

Values.

1937: As Table I. Coke (Gross and to producers)—24s. 7½d.
1943: " II. " " " " —45s. 3½d.
A: " III. " " " " —43s. 3½d.
B: " IV. " " " " —37s. 4½d.

COSTS—ALL IN PENCE PER THERM.	1937.	1943.	A.	B.
Coal	3.706	5.882	6.706	6.706
Capital charges	0.426	0.521	0.521	0.521
Labour charges	0.656	0.875	0.875	0.875
Coke to producers	0.543	0.999	0.955	0.824
Total	5.331	8.277	9.057	8.926
Less value of—				
Gross coke	2.822	5.193	4.966	4.286
Tar	0.349	0.454	0.454	0.454
Total	3.171	5.647	5.420	4.740
Net cost per therm ...	2.160	2.630	3.637	4.186
Net cost of coal	1.078	1.234	2.241	2.790

The scurfing period was every 16–20 weeks, and the weekly output per bed was about 6,500 therms.

Labour costs as taken from the wages analysis amounted to 44.6d. per ton of coal carbonized, and included wages for stokers, machine men, coal men, &c., and an allowance for technical supervision.

In regard to capital charges, unfortunately the plant was purchased in 1926, and it was therefore necessary to assume a capital charge figure so that results could be comparable with those of the verticals. This has been taken as 29d. per ton for 1937.

The value of all cost items is exactly the same as in Tables I, II, and III, except for coke, which has been corrected for 2% dust, instead of 7% as with the verticals.

In comparing results it must be remembered that Table V refers to a therm of 520 B.Th.U. cu.ft. gas compared with one of 450 in Table I. There is a reduction in the thermal yield to 68, while tar yield is only slightly over half that from the verticals. There is, however, an increase in the revenue from coke due to the elimination of steaming.

In 1937 a therm of horizontal 520 gas cost 0.579d. more to produce than a vertical 450 (at nominal throughput), and thanks to the good coke market this is approximately true to-day. If, however, the coal/coke ratio became 38s./44s., then the horizontal therm becomes 0.775d. more than the vertical, and at 38s. each it increases to 0.931d. more, which is to be expected in view of the greater importance of thermal yield as coal cost rises unless that of coke rises accordingly. Thus, the higher the calorific value, the lower is the gaseous yield, and the higher that of coke, so that the more dependent is the method of carbonization on a good price for coke relative to coal for a low cost per therm.

When deciding on the most economic system of carbonization, it is important to note that thermal efficiency is of secondary importance to the form in which the therms are recovered and their current monetary value. Thus the thermal yield of a horizontal bench may be higher than that of a vertical (usually it is some 3% lower), yet the financial value of the coke or tar therm may be such that the gaseous therm produced will be far more costly.

Water Gas (Blue and Carburetted)

Table VI summarizes costs of production of both blue and C.W.G. from results obtained on a pair of hand-operated down run sets, each of 500,000 cu.ft. daily capacity. Admittedly the sets do not represent modern practice, but in view of the rapid advances in water gas plant design in recent years, there must be many works similar to my own, whose load has not justified the purchase of fully automatic sets, and to whom these figures may be useful.

TABLE VI.—Water Gas Plant (Blue and Carburetted).

Plant: 2 sets Humphreys & Glasgow, Down Run, Hand Operated, 500,000 cu.ft./diem.
Coke: Vertical (screened, over 2 in.). Moisture: 3% av.

	1937.	1943.
Make/hr.: Blue water gas	19,000	C.W.G., 22,000.
Calorific value	290.	Calorific value 450, requiring 1.6 gall. oil per 1,000.
Cycle,	4½ min. run, 1½ min. blow	Cycle, 4 min. run, 2 min. blow
Values:		
Coke (merchant rate)	26s. 6d. per ton.	46s. per ton. 48s.
Tar	2½d. per gallon.	3½d.
Gas oil	5½d. per gallon.	11½d.
Steam	18d. per 1,000.	22d.
Wages	29d. per hour	38.5d.
Maintenance	2.2d. per 1,000 cu.ft. (C.W.G.).	3.52d. per 1000 cu.ft. (C.W.G.).

Costs—All in Pence per Therm.

C.W.G.	Per 1,000 cu.ft.	Per therm.	Per 1,000 cu.ft.	Per therm.	Per 1,000 cu.ft.	Per therm.
Coke, 36 lb./1,000	5.111	1.136	8.871	1.971	9.257	2.057
Steam, 32 lb./1,000	0.576	0.128	0.704	0.156		
Electric power	0.468	0.104	0.585	0.130		
Wages	1.318	0.293	1.750	0.389		
Gas oil	8.800	1.955	18.000	4.000		
Maintenance	2.200	0.489	3.520	0.782		
	18.473	4.105	33.430	7.428		
Less O.G. Tar, 0.24 gall.	0.600	0.134	0.780	0.173		
	17.873	3.971	32.650	7.255		
Blue.						
Coke, 45 lb.	6.388	2.203	11.089	3.824	11.571	3.990
Steam, 35 lb.	0.630	0.217	0.770	0.266		
Electric power	0.516	0.178	0.645	0.222		
Wages	1.526	0.526	2.026	0.699		
Maintenance	2.547	0.878	4.076	1.407		
	11.607	4.002	18.606	6.418		

The plant is maintained in first-class condition. Blowers are steam and electrically driven, results being given in terms of the latter. Electricity is generated on the works. Maintenance figures were actual, being taken over a period with the plant in continuous daily operation. The figures given in Table VI are for actual operating costs only, no allowance being made for technical supervision, capital charges (which vary so greatly with the use to which the plant is put), or maintenance of general plant, each of which must be in favour of C.W.G. as against B.W.G. production on account of the increased thermal output with the former, due to the use of oil.

It will be seen that the cost per therm has increased by 3.28d. for C.W.G. and 2.42d. for blue, due to the high cost of oil, and that whereas in 1937 carburetted was very slightly cheaper than blue, the opposite is now definitely the case.

A rise in price of oil of 2d. per gallon increases the cost per therm by 0.71d., while coke needs to rise by 16s. 7d. per ton to have the same effect.

On these figures any increase in coke value has approximately twice the effect on the price per therm of blue than carburetted.

To-day, more than ever, the economics of water gas have as their dominant influences the cost of coke and oil, and it is obvious without further figures that on present values the use of a horizontal and water gas mixture is not a very economic proposition, although any works which has made a practice of this in the past must inevitably be faced with the need of increased coal gas plant and gasholder capacity, involving high capital expenditure if any change is anticipated.

Benzole Recovery

Benzole recovery is now so general in view of its national importance, and its economics so closely interwoven with those of the retort house, that it cannot be overlooked in any consideration of the economics of gas production.

Results in Table VII refer to an oil-washing plant capable of washing 3 million cu.ft. of gas per diem while extracting 2 gallons per ton. The plant was purchased in the 12 months prior to the war. Capital charges were 12½% pre-war—*i.e.*, interest and sinking fund 10% and maintenance 2½%—and in 1943 these are increased to 14% (*i.e.*, maintenance 4%, interest and sinking fund as before), all based on the original purchase and installation price of £2,500. The general working conditions were similar to other such plants, except that, due to its low value, naphtha was returned to the washer. For comparison purposes results are given showing what costs would have resulted had similar figures been obtained in 1937.

TABLE VII.—Benzole Recovery.

Capacity of washer, 3,000,000 cu.ft. per diem.
Period under observation, Feb. 1 to May 31, 1943 (inclusive)—17 weeks.
Carbonizing plant, continuous verticals.

Yields.	Before recovery.	After recovery.
Gas (therms per ton) of coal carbonized	82	73
Coal carbonized (in period)	10,990 tons (*i.e.*, extra coal 12.5%)	12,364 tons.
Coke available for sale per ton	8.3 cwt.	8.7 cwt.
Tar (gallons per ton)	17 gall.	16½ gall.
Calorific value, Inlet washer	469.7 } Reduction in straight coal gas	
Outlet washer	450.2 } 19.5 B.Th.U./cu.ft.	

Crude benzole made, 31,880 gall. = 2.58 gall. per ton.
Naphtha made ... ... 5,409 gall. = 0.44 gall per ton.
Naphtha returned to washer, 5,955 gall.
Gas oil lost in washing, 1,527 gall. = 0.048 gall. per gallon of benzole.
Benzole test (av.) 100°C.—46.9 160°C.—83.0
$\frac{100}{160}$ = 56.5% Solvent naphtha 7.0%. Once run 76.0%
Grade B_1. Sp. gravity crude 0.826. Once run 0.827.
Sulphur in town gas, 10 grains per 100 cu.ft.

Cost of production.	1937.	1943.	
Average price received for benzole calculated on test above (per gallon)	12.963d.	15.565d.	
Wages (weekly), including tank loading and technical supervision	43s. 1½d.	57s. 6d.	
Gas oil—per gallon	5½d.	11½d.	
Water (per 1,000 gall. pumping only)	3d.	3.75d.	
Capital charges	12½%	14%	
Steam (per 1,000 lb.)	18d.	22d.	
Extraction costs (pence per gallon).			
Steam, 35.5 lb.	0.639	0.781	
Oil wastage, 0.048 gall.	0.264	0.540	
Water, 66 gall.	0.198	0.247	
Labour	0.276	0.368	
Electricity, 315 units weekly	0.168	0.210	
Int., S.F., and maint.	0.769	0.861	
Therefore total extraction cost/gall.	2.314	3.007	
Total production costs per gallon.			
Therm recovered calculated on—			
(*a*) *Net cost of gas into holder* per therm	3.49	4.42	
Cost of production: One gallon benzole = 1.6 therms × net cost into holder	5.584	7.072	
Extraction cost per gallon	2.314	3.007	
Total cost of production per gallon	7.898	10.079	
Therefore profit per gallon	5.065	5.486	
(*b*) *Net cost of coal.*			
Coal/coke ratios	23s./27s.	38s./46s.	38s./42s. 6d.
Purification per therm	0.07d.	0.10d.	0.10d.
Additional maintenance (retorts and coal handling) per ton	1s. 3d.	2s.	2s.
Net coal cost.			
With benzole recovery, expenditure on coal less revenue from residuals (excluding that from benzole)	£4,840 10 0	£8,358 11 0	£9,304 8 0
Without benzole recovery, expenditure on coal less revenue from residuals	£4,535 4 0	£7,861 1 0	£7,861 1 0
Therefore net coal cost used in benzole production	£305 6 0	£497 10 0	£1,443 7 0
Additional retort and handling maintenance 1,374 tons	85 17 0	137 8 0	137 8 0
Additional coke to be handled 817 tons	61 6 0	81 14 0	81 14 0
Therefore net cost of coal plus handling and retort maintenance	£452 9 0	£716 12 0	£1,662 9 0

Cost of production (pence per gallon).

Net cost of coal (plus handling and retort maintenance) per gallon	3.406	5.395	12.515
Purification (1.6 therms) ...	0.112	0.160	0.160
Extraction costs	2.314	3.007	3.007
Total cost of production ...	5.832	8.562	15.682
Therefore profit per gallon ...	7.131	7.003	0.117 (loss)

It will be noted that operating costs are calculated primarily exclusive of the value of the gaseous therm recovered as benzole, which, due to its importance, is considered separately. While most writers are agreed fairly closely on the former cost, it is seldom that they do on the latter, due to either varying fuel prices, works efficiency, or their treatment of its value. When considering the value of the therms displaced the plant may be regarded as either:

(*a*) A gas consumer—so that the plant is debited with the cost of the gaseous therms recovered as benzole. When treated thus it is at once obvious that here is a consumer who requires no storage or distribution charges whatever, so that it is unfair to charge gas to the plant at its value to the average consumer. Further, this assumes that if recovery ceased there would be an immediate sale for those therms as gas, which is not so. The cessation of benzole washing would result in the carbonization of less coal, but the volume of gas sold through the station meter would be the same. It is usual, therefore, to charge the therm at the net cost into holder. This cost is, however, dependent on the load—*i.e.*, the nearer the plant is worked at maximum capacity the lower are the overheads, and the lower the cost into holder, so that its value is naturally higher in summer than in winter. In calculations the average cost during the year must be employed. Calculated thus, Table VII shows that the net profit per gallon in 1937 was 5.065d. against 5.486d. in June, 1943.

(*b*) An adjunct to the retort house which provides a new by-product, and also a means of increasing the flexibility of the carbonizing plant and of regulating gas quality. The plant should now be debited with the net cost of the extra coal carbonized, plus an allowance for purification of the gas, since it was installed at the outlet purifiers. Since the retort life is usually reckoned in tons of coal carbonized (or if possible therms made), it follows that the extra coal must be charged with a sum sufficient to cover the additional retort and coal-handling plant maintenance, as these are being worn out whether gas or benzole is being produced, although it is admitted that the stabilized load and reduced steaming must tend to increase the retort life. For 1937 calculations, additional maintenance was charged as follows: Retorts, 11d. per ton; coal handling (tipper, conveyor, hoppers, &c.), 4d. per ton, giving a total of 1s. 3d. per ton, which, increased by 60%, means 2s. per ton for 1943. Similarly, additional coke has to be handled, and 1s. 6d. per ton in 1937 and 2s. in 1943 have been allowed for this purpose.

In our case benzole recovery did not necessitate any additional labour in the retort house. No attempt has been made to assess the financial benefits accruing from reduced sulphur and naphthalene content of the gas. The writer considers this to be the fairest method of assessing the value of the therm removed by washing, and calculated thus, results in Table VII show the 1943 profit to be 7.003d. per gallon, while similar results in 1937 would yield 7.131d. per gallon.

The most important item in the balance-sheet is in the value of the therm recovered as benzole. This figure is dependent on the relative value of coal to residuals, so that it follows that before any voluntary decision is taken to recover benzole, it must be ascertained that there is a good market for the extra coke, without affecting its value, and that the coal carbonized is such that recovery is possible without high thermal loss, or the necessity to purchase coal at a higher cost from a more distant coalfield. If the extra coke made should affect the coke market adversely, the serious effect of this on benzole profit is shown by considering the position if, after recovery, the value per ton fell by 3s. 6d. This would have the effect of converting the profit per gallon into a loss of 0.117d. per gallon.

Summary

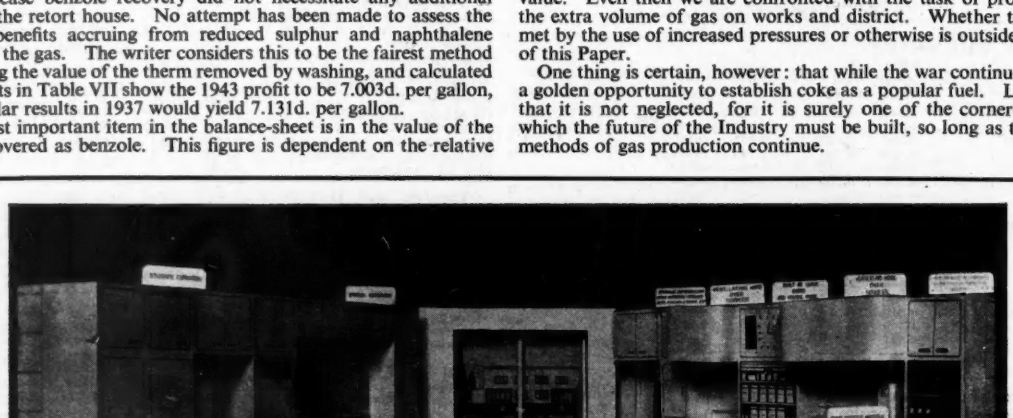
Briefly the position on the works may now be stated thus:

1. It is still true that "profits are made and lost in the retort house."
2. Coal gas is cheaper than blue or carburetted water gas.
3. Blue water gas is cheaper than carburetted due to the high cost of oil.
4. Cheapest therm of coal gas is obtained from the setting giving most therms per ton.
5. Economics of the retort house are mainly dependent on relative value of coke to coal.
6. Economics of benzole recovery are mainly dependent on relative value of coke to coal.
7. Economics of water gas production are mainly dependent on cost of coke and oil.

Post-War Years

Thus we see to-day, more than ever, that the hinge on which the economics of gas production swings lies in the relative value of coke to coal, and there is little to indicate that it will be otherwise in the future. Benzole recovery has thrown more coke on the market, and we can visualize the result when the exceptional war demand has finished unless everything is done at once to obtain, and maintain, a good market for it. The foundation-stones of our efforts should be good salesmanship of a sized product of excellent quality for burning in properly designed appliances, and our aim to educate the public in its use to the extent that saleable coke is cleared by demand without resort to stacking (except the minimum that may be necessary in summer to cover our winter commitments), with the resultant high labour costs required to reclaim a product reduced in quality by exposure, and in value by increased breeze content due to abrasion. Even so, we must expect reduced returns for coke, and possibly tar, while coal prices remain fixed, or even rise. Production of coke is determined by the consumer's demand for gaseous therms, and under these anticipated coal/coke/tar ratios the only logical solution, if there is not the demand for coke and tar in keeping to gas produced, is to increase the gaseous therms and reduce those of coke and tar—namely, lower the calorific value. Even then we are confronted with the task of providing for the extra volume of gas on works and district. Whether this will be met by the use of increased pressures or otherwise is outside the scope of this Paper.

One thing is certain, however: that while the war continues we have a golden opportunity to establish coke as a popular fuel. Let us hope that it is not neglected, for it is surely one of the corner-stones on which the future of the Industry must be built, so long as the present methods of gas production continue.



A Housing Exhibition was recently held in Bath, arranged by the City authorities, and the Bath Gas Company designed a model kitchen as an integral part of the plans for a proposed post-war house, three-bedroom type, to be built on Council or similar estates. Our photograph illustrates the model of the kitchen, ½th full size, as shown at the exhibition, and as at present in the Company's showroom window, where it is drawing large crowds. The model represents a kitchen 15 ft. long by 8 ft. wide, but for demonstration purposes the walls have been opened out. The house, which may or may not be of pre-fabricated material, is designed around a central duct (inside dimensions, 3 ft. 6 in. by 2 ft. 6 in.), which is accessible by the removal of a panel fitted in the back of a coat cupboard in the front hall, and provision has been made for working room in the bottom of this duct for all services.

CONSERVATION OF RESOURCES*

By Dr. E. S. GRUMELL, C.B.E.

THE title chosen for this Lecture is "Conservation of Resources," and one of the reasons why this title was chosen is as follows: In his Presidential Address to the Institute of Mining Engineers in 1940, the late Mr. Forster Brown concluded that whereas in Germany the average life of the collieries at the current rate of output was 185 years, the average life of our collieries was 75 years, and if only the seams being worked in 1940 be considered, the average life is no more than 45 years. So far as is known this statement has not been challenged; on the contrary, there are some who are of the opinion that our best and most easily won seams will be substantially exhausted within the next 30 years, and that coal will be very costly unless greatly improved methods of mining are invented.

There is no particular reason to believe that this is a false alarm. One cannot view without concern the fact that the output of Lancashire is now only something of the order of 50% and that of Scotland something of the order of 75% of what it was some 30 years ago.

Further, the fear has been expressed that there may be a shortage of certain types of coal—for instance, strongly caking coals—and it has been urged that their use for steam raising and furnace work should be prohibited, but this wants a little further consideration. At the present moment there is a tendency for there to be a surplus of these coals in districts where they are not particularly needed. Geographical location is one part of the problem, but there is another aspect to be considered. What has been the direction of usage in recent years? Formerly the Gas Industry carbonized solely in horizontal retorts and used strongly caking coals. Now some 50% of their coal is carbonized in vertical retorts which use medium caking coals—precisely some of the best coals for steam raising, gasification in producers, and general industrial use. It may therefore be that in the future the shortage may be of this type, and not of the highly caking coals.

Now all this has an important bearing on any proposed new developments, such as oil and chemicals from coal, and on export policy, and emphasizes the need for continuing and greatly extending the fuel efficiency campaign after the war. It may well be that conservation of resources may have to be the keynote of the future.

It is quite clear that no comprehensive planning or research can be initiated until it is known how much of each type of coal we possess and can expect to bring to the surface under economic conditions. The necessary survey is in hand, and it has been stressed that what is required is not a report accurate to the first decimal place, which would take 2–3 years to prepare, but one giving a first approximation which can be used as an immediate guide.

Not only is there required a survey of resources, but there is also required a survey of requirements. There is already a certain amount of information available on this subject, and the Ministry of Fuel and Power has taken steps to amplify it considerably. However much we may dislike filling in forms it is essential that we should know more about our requirements, and here I would suggest that we need a certain measure of cross-indexing on the lines indicated in Mr. Roskill's Paper. In consumption statistics the gas, electricity, and coke ovens industries are debited with some 60 to 70 million tons—or roughly one-third of our coal. Now that may be slightly misleading. Actually the carbonizing industries *process* coal to the extent of 41 million tons, but while they *consume* something of the order of 8 million in the processing, they *distribute* the equivalent of about 33 million tons to other consumers. This tonnage does not appear in statistics charged against individual industries and the domestic consumer.

As a result of this method of recording consumption, the iron and steel industry, for instance, is debited in statistical records as consuming only some 11 million tons of coal, whereas actually it consumes some 25 millions or more of fuel—if under "fuel" one includes the coke made at coke ovens and passed on to the steel industry. The steel industry is the *consumer* of the greater part of the coke made at the coke ovens.

Similarly, some of our minor industries appear from statistical records to be relatively small consumers of fuel, but on investigation it has been found in more than one case that they are substantial consumers of fuel, but fuel in the form of gas, electricity, or coke which is not recorded against them, the coal for such fuel having already been entered against the parent processing industry. Only raw coal is entered against each industry. Therefore, if we wish to obtain a true picture of the distribution and consumption of energy in this country, all forms of energy, correctly related back to coal, should be accurately debited to where it is used. When this is done we shall be in a position to calculate the total energy per unit of production—which may be a ton of steel, a pound of laundry, or the boiling of the weekly egg—and find out how inefficient our usage of energy really is.

This is a subject to which the Fuel Efficiency Committee attaches very great importance. It is essential that we should, in all cases, know the actual energy used in any operation, and be able to compare it with the theoretical requirements. That previous statistics have been misleading and ought to have been cross-indexed is shown by the now known fact that the amount of energy used for space heating in factories, offices, and buildings is considerably greater than it was thought to be before the war. We all take for granted the amenities of lighting and heating in factories and offices, but really this may be a technical fuel efficiency problem of equal importance to the development of high-pressure boilers or improvements in glass and steel furnaces.

Even now we do not appear to have a reasonable estimate of how much of our dwindling resources are used annually to maintain our domestic and semi-industrial amenities, but it is becoming increasingly evident that the efficient heating, insulation, and lighting of buildings, &c., is a matter of great national importance. There is also considerable scope for saving of energy by planning the location of factories and industrial establishments, such as laundries, in such a way that their requirements of steam, hot water, and power could be derived from the surplus plant or waste heat of neighbouring factories.

As part of future planning it is essential that we should have, in the first place, at least an approximate estimate of our practical resources. We cannot reasonably plan new processes or development of existing methods until we know how much of each type of coal we possess and can expect to mine economically.

Secondly, if we wish to conserve resources by being more efficient in the use of what is at present available, we must have a few more facts about our present requirements—more facts about how, and where, and why our various forms of energy are used.

In view of rapidly decreasing reserves and rapidly increasing costs—especially increasing costs relative to those of other countries—I am of the opinion that coal should be regarded as an asset to be mined, prepared, transported, and utilized as economically as possible, and in order to achieve this I think that consideration of all fuel problems should, in principle, start at the colliery itself. All our previous procedure, including unrestricted inter-colliery competition and technical efforts on the part of consumers to make profits out of unfairly low-priced coals, might well be revised. We might well ask the coal industry to examine and report on what sizes, qualities, and types of coal it can most cheaply and efficiently mine, prepare, and transport; then industry and the domestic consumer should, in collaboration with appliance makers and fuel technologists, study these products, and say either "Yes, we can design appliances and develop processes to use these products efficiently," or "No. We can be more efficient if we have something different, but of course we are prepared to pay, and can afford to pay for the extra cost of mining and preparation." If considered carefully this is a logical proposition. The trouble is that there are still a few people who think that perfect coal should be marketed to suit consumers at the cost of low dividends and poor wages in the coal industry.

The main idea behind this is to avoid placing on the coal industry any avoidable restriction which would increase the cost of mining, or prevent a decrease, and to allow them to formulate plans for the cheapening of production and preparation. Viewed rationally the ultimate interest of most industrialists and domestic consumers will be to help in reducing costs of production and preparation. This is, of course, particularly important to those industries concerned with export and foreign trade, who view with grave concern the disproportionate increase in costs in this country compared with, for instance, those in America.

It is, for example, often stated that methods of mining have been restricted by the need to produce as much large coal as possible on account of the higher price it fetches. If this be true—and there is reason to suppose that it is—it shows that one of the first things to be done is to devise and stabilize a fair price structure, by which is meant a fair relative value for different sizes, qualities, and types of coal. Even before the war the price structure was unsatisfactory. Sometimes it was unfair to the producer, who received an inadequate reward for preparing coal of high quality and regularity; at other times it was unfair to the consumer, who had to pay an unreasonably high price for a relatively inferior material. Since the war the structure has become still further unbalanced by an equal flat rate increase on all coal.

In the interest of sound technical and commercial development it is essential that a rational price structure should be evolved and stabilized as soon as possible. I would quote the experience of the use of coke breeze as an example of unsound development. First it was a drug on the market; then plants were put in to use it by enterprising individuals at appreciable capital and maintenance cost. As a result demand increased, and prices rose until the point was reached when it became no longer worth using. Then it again became difficult to sell. My company was one of the first to use coke breeze and we just about got a return on our capital. Before the war we had ceased to use it.

The problem of price structure is of immediate importance to the coal industry, for many collieries are planning the reconstruction of their preparation plant, but desire to know, in advance, the future

* Abstract of the Melchett Lecture to the Institute of Fuel.

values of different qualities and sizes. Some are wondering whether cleaning plants are necessary in all cases. Faulty and unstable price structures have not only led to wrongly directed development, but have held up developments of great importance. It is—among other reasons—probably due to faulty price structure that the great asset of British coals—*viz.*, their natural low ash content and easy cleanability—has not been exploited. A recent communication from America states that a 1% reduction in the ash content of coke will increase the rate of iron production from 3 to 6%, and reports from our own industry confirm increase of output and reduction of fuel consumption with low ash coke. Evidence has also been submitted to show that low ash coal has many advantages in the Gas Industry.

It is almost incredible and really a serious reflection on our technical and commercial ability that a problem of this nature has not been seriously considered except in scientific Papers. On the consumers' side the industries particularly interested have not produced very conclusive and reliable evidence, and the producers have been frightened by pre-war price structure and the fallacious fear of loss of yend in preparing low ash coal. The failure to solve a problem of this nature is an excellent example of pre-war lack of collaboration.

Now, while I believe that in suitable cases it will be shown that the preparation of clean coal is desirable, I believe that in many other cases —given a correct price structure—it may be unnecessary to go to the expense of cleaning at all.

Within the last ten years considerable advances have been made in methods of sampling and in the application of statistical methods, and there is reason to believe that these weapons would enable a study to be made of when and where the dirt comes from, and why. Such a study might avoid the need for cleaning. In other words, prevention may prove cheaper than cure.

Mr. R. Burrows, in a very valuable Paper, raises this question of the need for cleaning, and says that regularity of quality is the crux of the matter. The subject of regularity of variability is discussed in this Lecture, and an example is given of a dry slack averaging 9% of ash with extreme limits of 7–11%. This slack is as regular in calorific value as many a prepared fuel, and is eminently suitable for many industrial purposes without any further cleaning.

The problem of cleaning and sizing is one of simple arithmetic. Cost of cleaning and transport *versus* technical advantages in utilization—a problem to be answered by a greater knowledge on the part of the coal industry of industrial uses, and a greater knowledge on the part of the consumer of the cost of preparation and willingness to pay for it. Certainly, steps should be taken to prevent a repetition of a position which has led to such a multiplicity of sizes and qualities being produced that a representative Committee has had to be appointed to recommend simplification—a multiplicity which complicates the price structure and makes it almost impossible to alter prices except on a flat rate basis.

Now to pursue the idea of starting at the colliery for progress, what is the biggest problem in connexion with methods of mining, preparation, utilization, and price structure? It is how to deal with the fines (material less than $\frac{1}{4}$ in. or $\frac{1}{16}$ in.).

It is generally agreed that if fines could be removed from coal many of the problems of appliance makers and fuel technologists would disappear. This separate removal and treatment is not a new suggestion. In a recent bulletin of the University of Illinois it is argued that fine coal should be separated and dry cleaned, and that large coal should be wet washed. A removal of fines might, in some cases, avoid cleaning of the larger coal; for instance, in the previously quoted case of a dry slack with 9% of ash, the fuel could be separated into 1–$\frac{1}{4}$ in. with 7% and $\frac{1}{4}$–0 in. with 13%. Separate removal might have some advantages from the coal industry's point of view in mitigating the slurry problem, to solve which much time, money and thought has been expended on flocculation, froth flotation, filter pressing, drying, &c.

One is inclined to suspect that the problem has been regarded just as a nuisance (which it certainly is), and that the industry, never having anticipated getting a reasonable price for the fines, has regarded the solution from a negative angle. It is not impossible that if the problem were attacked from a positive angle, designers of plant might be encouraged to produce much better equipment. Why is it that the use of pulverized fuel, so extensively employed in the States and on the Continent, has not been developed in this country? Why is there no example of the Kramer system in England? There is, at Leicester, a power station which buys ordinary slack and then screens it, using the fines for pulverized fuel and the graded coal for stokers. This seems to be suggestive.

It is not submitted that separate removal of fines is the best or the only solution. What is suggested is that this is a most important technical and commercial problem awaiting solution, and that the pros and cons should be examined in the light of fair relative prices and on the basis of a technical cost statement.

Professor Bryan has said that "War always steps up ideas in engineering and other fields." We must realize that we may be going to live in a new age and that there must be some sort of systematic planning, not between isolated pits and isolated consumers, but between the coal industry, appliance makers and consumers in general. The time is long overdue when producers and consumers should meet to discuss their respective difficulties and requirements, both technical and commercial, in order that the national asset—coal—may in future be produced and utilized at maximum efficiency.

Research and Development

With regard to research and development, in the first place I think that all research at present in hand or contemplated should be examined as to priority, and preference should be given to investigations which will help in reducing the present inefficiency of utilization. I do not mean by this that all so-called long term research should be shelved, and I realize that it is often very difficult to decide which problem is most important, but there are problems of immediate urgency, such as the best utilization of fines, and many problems connected with combustion and heat transmission, and the effect of size of coal on performance, discussed in the paper, which have been previously neglected and which should now receive preference. Surely when we know that some furnaces are operating at no more than 5% thermal efficiency, we ought to concentrate our efforts more on day-to-day problems.

I am also of the opinion that future developments should be planned on a much larger and more ambitious scale. If, for instance, in pre-war days, it would have taken ten years to develop such a process as total gasification, it should, in future, especially with our greatly increased scientific knowledge, be accomplished in less time—say, in three years. Many years elapsed between my first experiment on hydrogenation and the starting of the plant at Billingham. Looking back on this experience it seems possible that, given the necessary staff and finance, it could have been done in less time. I do venture to suggest that if total gasification, for instance, is a major industrial problem, it should be approached not by the erection of one experimental Lurgi plant, but by the erection of at least five or six in suitable gas-works, with adequate research staffs.

On the subject of coke oven research it seems desirable that this should be considerably extended. The research associations have been handicapped by lack of funds and lack of suitable plant for investigations, and their work has been on altogether too small a scale. At least one battery of ovens should consist of a set of ovens fully instrumented and equipped for experimental purposes. There are many other sections of industry where this policy might be adopted with advantage. For instance, how much real progress has been made in underground gasification is not known, but I would suggest that it should be tried in this country on one of the outcrops. It would not be a costly matter to sink shafts 50 to 100 ft. deep. When the experiment is concluded the overburden could be removed and one could see what had happened in the seam. There is one obvious objection—namely, that the overburden may not be representative—but in spite of this I think some useful preliminary experience might be gained.

Investigations of this nature cost money, and the Parliamentary and Scientific Committee has already stressed the importance of national funds being provided. One might ask if the Government could not find some way of diverting a fraction of the savings which are being made as a result of the Fuel Efficiency Campaign into a Research Fund. The savings must already amount to many millions of pounds sterling.

Another very important point is to reduce the time lag between research and application, to get a greater number of industrial workers interested in research, and to get the results of research more widely disseminated. Pre-war, in this and other countries, fuel research was frequently carried out in special stations by special staff—often a staff of scientists with little or no industrial experience. The work was carried on for two, three, four, five years without people outside knowing very much of what was going on, and even when the results were published there was usually a further time lag between presentation of results and application. An interesting example of this has recently occurred. In 1938 my colleagues showed that a high primary air rate on travelling grate stokers is useful in reducing the swelling of caking coals. It is only now that this is being applied.

A very promising move to bring industrialists and research associations closer together in the study of practical fuel problems has recently been made by the appointment of an organization sponsored by the Association of Shell Boiler Makers and the Stoker Makers' Association in collaboration with B.C.U.R.A., various Government departments, and the Ministry's Fuel Efficiency organization. Most of the large-scale work will be carried out in industry, and it is hoped to get the assistance and interest of a large number of engineers, and thereby to bring about much closer contact between industrialists and scientists, and to foster a greater knowledge of the performance of British coals.

I might add that somewhat similar organizations have been and are being set up to study other fuel problems. The coal industry has set up a panel to study the use of low-grade fuels.

In considering the future there is an unknown factor to be borne in mind. What will be the effect of the extensive education courses initiated by the Ministry of Fuel and Power in collaboration with the Board of Education; the special training in fuel of post-graduate engineers arranged by the Ministry; the appointment of Fuel Efficiency Officers and Committees in all industries; the outstanding work of the Regional Committees? As a result of these various activities there is now, in this country, a much greater number of people interested and experienced in fuel problems. Incidentally, everybody's experience has been greatly widened by the dislocation of normal fuel supplies, which may well prove to have been a blessing in disguise.

It is almost a certainty that these manifold activities will have a great stimulating effect on development in the future, and may bring

some badly needed new views to bear on the subject of "conservation of resources." We want some new blood circulating in the fuel body.

In conclusion, may I remind you that the Fuel Efficiency Committee includes representatives of gas, electricity, coke, railways, coal, iron and steel, oil and general industry, together with Government departments and the directors of F.R.B. and B.C.U.R.A., all serving in a private capacity. I can assure you that the exchange of views between these varied interests has been extremely friendly and most instructive, and as a result of these contacts during the last two years I am convinced that the greatest and most rapid progress can best be made by "combined operations"—that is to say, not by each industry going its own way regardless of other interests, but by a reasonable collaboration between industries and by an interchange of technical knowledge relating to fuel production and utilization, such as is being so satisfactorily developed to-day. If we can avoid a reaction after the "cease fire" and continue to carry on as we are doing at present, making full use of the new national fuel consciousness and enthusiasm, I feel sure that we shall achieve that reduction in consumption which is essential for our future prosperity.

THE PROCESSING OF GAS LIQUOR

The following is the reply of Messrs. Baird and Parrish to the discussion on their Paper to the North British Association of Gas Managers on Sept. 3—see "JOURNAL" of Sept. 8:

Concerning the pertinent observations of Mr. J. Dickson, hitherto it has not been difficult to establish a case for the concentration of gas liquor, as opposed to the continuance of the manufacture of sulphate of ammonia, and the important number of gas undertakings throughout the country, of large, medium, and small size, now producing concentrated gas liquor reflects the consideration given to the economics of this subject under various conditions, and the marked unanimity of opinion reached as to the desirability of production.

Clearly, if a comparison is to be instituted between the two costs of production, it should be made on a comparable basis. If 15% is to be the charge for interest, sinking fund, and obsolescence in connexion with the manufacture of concentrated gas liquor, then in common fairness this basis of charge must be debited against sulphate of ammonia manufacture.

The capital value of a sulphate of ammonia plant and buildings, including normal equipment, of the size of Dundee would be of the order of £10,000, and as gas-works accountancy generally provides for the maintenance of a plant in good condition and order, a 15% charge represents £1,500 per annum, or:

$$\frac{£1,500}{946 \text{ tons sulphate made}} = 31s.\ 10d. \text{ per ton of sulphate.}$$

Contemplating such a charge, it will be seen that the profit indicated by Mr. Dickson on sulphate of ammonia practically disappears.

But it cannot be said that the costs of manufacture of sulphate of ammonia are covered by acid, steam, maintenance, and labour. There are many other items of production cost, such as effluent treatment, bags, cost of bagging and loading, rents, rates and taxes, lighting, cooling water, chemical and engineering supervision, sales expenses, and allowance to farmers and/or mixers. When all these aspects of cost are taken into full consideration, generally speaking a case cannot be established for the continuance of sulphate of ammonia manufacture. What renders this impossible more than ever is the high cost of chemical sheet lead, costs of suitable timber, and the sensibly reduced realizable price for scrap lead.

The excessive use of sulphuric acid can arise in two ways. If arsenical sulphuric acid is to be used because of its more attractive price, it will be found that there is loss of both acid and sulphate in attempting to separate the arsenical sulphide resulting in the process, by whatever method is adopted. Moreover, any sulphates, other han ammonium sulphate, which the sulphate of ammonia contains will account for additional sulphuric acid consumption.

TONS OF 70% SULPHURIC ACID REQUIRED PER TON OF SULPHATE OF AMMONIA, WITH VARYING CONTENTS OF H_2SO_4.

% Nitrogen.	% $(NH_4)_2SO_4$.	Tons 70% (123° Tw.) sulphuric acid per ton of sulphate of ammonia.					
		Nil.	0.05% H_2SO_4.	0.10% H_2SO_4.	0.20% H_2SO_4.	0.50% H_2SO_4.	1.0% H_2SO_4.
21.20	100.00	1.0600	—	—	—	—	—
21.00	99.05	1.0499	1.0506	1.0513	1.0528	1.0570	—
20.80	98.12	1.0401	1.0408	1.0415	1.0430	1.0472	1.0544
20.60	97.17	1.0300	1.0307	1.0314	1.0329	1.0371	1.0443
20.40	96.22	1.0200	1.0207	1.0214	1.0229	1.0271	1.0343
20.20	95.28	1.0099	1.0106	1.0113	1.0128	1.0170	1.0242
20.00	94.33	0.9999	1.0006	1.0013	1.0028	1.0070	1.0142
Tons of 77.17% (140° Tw.) sulphuric acid required per ton of sulphate of ammonia.							
21.20	100.00	0.9615	—	—	—	—	—
21.00	99.05	0.9524	0.9530	0.9536	0.9550	0.9588	—
20.80	98.12	0.9435	0.9441	0.9447	0.9462	0.9499	0.9564
20.60	97.17	0.9344	0.9350	0.9356	0.9370	0.9408	0.9473
20.40	96.22	0.9253	0.9259	0.9265	0.9280	0.9318	0.9382
20.20	95.28	0.9163	0.9168	0.9174	0.9189	0.9227	0.9292
20.00	94.33	0.9070	0.9077	0.9083	0.9099	0.9137	0.9202

Again, where weak gas liquor is distilled, the steam-ammonia stream, in the absence of partial dephlegmation, may lead to the formation of excessive mother liquor and loss of sulphuric acid and sulphate of ammonia may occur here.

Assuming there is no loss from the two sources indicated, the consumption of sulphuric acid per ton of sulphate of ammonia depends on the nitrogen (or ammonia) and free sulphuric acid contents of the sulphate of ammonia. The preceding table in this connexion will doubtless be of wide interest.

The aspects raised in the discussion by Mr. Sydney Smith are extraordinarily interesting, and merit careful examination. The absorption of H_2S in oxide of iron purifiers is expensive in any case: it may be slightly more expensive in small oxide of iron heaps such as are a common feature of the equipment of concentrated gas liquor plants, and the retention of H_2S as ammonium sulphide in the concentrated gas liquor is therefore profitable.

The larger aspect which Mr. Smith has in mind is equally important. Clearly, ammonia should be used to the fullest possible extent in the absorption of H_2S, so as to reduce to a minimum the quantity of H_2S to be dealt with in the crude gas at the oxide of iron purifiers.

There are several qualities of concentrated ammonia (impure) in aqueous solution derived from the treatment of gas liquor, and these need to be defined from the viewpoint of their use. The following table attempts to give a succinct definition:

Quality.	Approximate analysis. NH_3 by weight.	H_2S by weight.	CO_2 by weight.	Use.
1. Concentrated gas liquor ...	15%	2%–3%	15%–18%	... Manufacture of soda ash (ammonia-soda process, or for manufacture of sulphate of ammonia.
2. Concentrated gas liquor ...	20%–22%	2%–10%	18%–21%	... The ammonia for sulphate of ammonia manufacture and hydrogen sulphide for sulphuric acid manufacture.
3. Concentrated ammonia liquor ...	15%–25%	Not exceeding 1%	Not exceeding 1%–2%	... For manufacture of liquor ammonia for conversion to nitric acid or for the production of commercial ammonium carbonate, or ammonium bicarbonate powder.

The cheapest product to make is No. 1, although No. 2 does not involve much extra expense. But the manufacturing cost of concentrated ammonia liquor with the low percentages of H_2S and CO_2 indicated is relatively more expensive. Evidently Mr. Smith sells his product to a firm manufacturing commercial ammonium carbonate. Obviously this firm will seek to obtain a product containing a minimum of H_2S. There is reason to believe that the present average recovery of ammonia is less than 5 lb. per ton of coal carbonized, whereas a much higher figure is capable of achievement, and is, indeed, to be desired.

Where "Arca" controls have been adopted it has always been standard practice either to use a governor, in the way outlined by Mr. Smith, or where sufficient head is available, to install a constant level tank.

As regards the written remarks of Mr. David Fulton, it is conceivable that there are circumstances at the present time which would admit of revenue being derived from the treatment of gas liquor in the manufacture of concentrated gas liquor, starting from scratch. It is evident from Mr. Fulton's observations that he has a clear appreciation of most of the aspects stressed in the Paper.

It would be difficult to justify the use of copperas in the treatment of gas liquor with a view to reducing its corrosive properties. The effect of the addition of ferrous sulphate would be to react with ammonium sulphides and ammonium carbonates, and this would absorb a good deal of copperas apart from that which is required to react with the ferrocyanides and thiocyanates of the gas liquor.

At the present time an investigation is being made about the wisdom of admitting air after, instead of before, the scrubbing system, with a view to restricting the formation of thiocyanates and thiosulphates in the scrubbing medium. But it will be some time yet before one can assess accurately the merits of such a procedure. Certainly, by admitting air after the scrubbing system the effluent liquor arising from the distillation of gas liquor will contain less thiocyanates and thiosulphates and will therefore be less toxic; but whether such gas liquor will be less or more corrosive of distillation units and their equipment remains to be seen. Hitherto it has always been deemed advisable to use gas liquor containing ammonium sulphide, because the formation of iron sulphide in the distillation units and other auxiliary plant has a marked protective influence against corrosion.

The Housing Design Exhibition of the Incorporated Association of Architects and Surveyors, which had a very good run at Selfridge's, has now been transferred to Bristol, in the premises of the Bristol Gas Company, Radiant House, Colston Street. It includes a Plan for Bristol by the local members of the Western Counties Chapter of the I.A.A.S., as well as the designs and models submitted for the Association's Open Competition. The Exhibition was opened to-day by the President of the I.A.A.S., and remains open daily until Nov. 3.

EFFECT OF SPENT GAS LIQUOR ON COLD SLUDGE DIGESTION*

By A. SCIVER and E. H. M. BADGER

IN 1934 the sewage disposal works of the Windsor R.D.C. at Ascot consisted of three filters, a balancing tank, a humus tank, and sludge beds, and was designed to deal with a population of 9,000, the actual pre-war population being about 6,700. In the early part of the war the population rose to 13,000–14,000. The average daily volume in 1941 was 425,000 gallons, and in 1942, 356,000 gallons. The sewage gravitates to a pumping station, and is pumped from there through a 12 in. diam. rising main for about 4½ miles to the disposal works. Owing to the long pumping main the sewage arrives at the works in an unusually septic condition, being black in colour and malodorous.

In November, 1936, sludge digestion tanks of the non-heating type were constructed. There are three open primary sludge digestion tanks, each of 405 sq.ft. surface area with a total cubic capacity of 16,000 cu.ft. There are four open secondary sludge digestion tanks, each of 258 sq.ft. surface area with a total cubic capacity of 10,000 cu.ft. The capacity per person was therefore 4 cu.ft. before the war, and 2 cu.ft. when the population increased to 13,000–14,000. It is held by some observers that a capacity of 4 cu.ft. per person is somewhat low for unheated digestion.

In 1935 the discharge into the sewers of spent gas liquor from a concentration plant up to a maximum of 1,000 gallons per day began. In February, 1939, this discharge was discontinued at the wish of the Windsor Rural District Council.

During the period when gas liquor was being discharged no trouble was experienced with the quality of the final effluent and no complaint was received from the Thames Conservancy. Unfortunately, however, trouble had been experienced with sludge digestion, which in fact had never operated properly up to the time when the spent gas liquor was cut off. Samples taken in September, 1937, when gas liquor was being discharged, showed that the sludge was acid, whereas in April, 1940, when the gas liquor had been cut off for 14 months, it was alkaline. Subsequent experience, however, has shown no evidence that this difference was due to gas liquor.

On Feb. 22, 1939, the Ascot District Gas and Electricity Company applied to the Windsor Rural District Council under the Public Health (Drainage of Trade Premises) Act, 1937, by Notice pursuant to Section 2, for permission to discharge trade effluent into the sewers, the maximum volume to be discharged on any one day being 1,920 gallons, and the maximum hourly rate being 80 gallons. The analysis given in the Notice was:

	Pts. per 100,000.
Free H_2S	*Nil*
Free ammonia	*Nil*
Fixed ammonia	391
Oxygen absorption (4 hrs. 27°C.)	1,039
Phenols	251
Thiocyanates	35
Chlorides as Cl_2	745

This application was refused by the Council, and the Gas Company thereupon appealed, under the Act, to the Ministry of Health. This was the first appeal of its kind, and was heard at Ascot Police Court on April 25 and 26 and May 6, 1940, before Mr. Wells and Dr. Parker, of the Ministry of Health.

On Oct. 16, 1940, the Ministry promulgated its findings at a meeting of both parties at the Ministry. Mr. Heatherington said that "it seemed that this was a case in which the trade effluent should be admitted to the sewers, subject to certain conditions, for treatment in admixture with the sewage of the district. Gas liquor effluent was being admitted to the sewers of the local authorities in many parts of the country, and without causing any undue difficulty at the sewage disposal works. It was the most satisfactory method of dealing with gas liquor effluent in most instances. The Windsor Rural District undoubtedly had a difficult problem in that, owing to the long length of the main from the Pumping Station to the Sewage Disposal Works, the sewage was in a septic condition on reaching the Works. It would also seem that in the past the gas liquor effluent had perhaps not been admitted to the sewer at controlled rates of flow. It had probably been admitted in flushes. . . . It seemed, however, that up to the time of the enquiry satisfactory sludge digestion under alkaline conditions had never been established at the sewage works."

The Ministry suggested that the sludge should be removed daily from the collecting tank and the primary sedimentation tanks. For a time the quantity of sludge transferred to the digestion tanks should be reduced until satisfactory alkaline digestion had been established. During this period any excess sludge should be run direct to the sludge drying beds. When alkaline digestion had been established, the quantity of sludge transferred to the digestion tanks should be increased to ascertain whether the digestion tanks were sufficiently large to deal with the domestic sewage. If so, then spent gas liquor might be admitted in gradually increasing regulated quantities.

The admission of the gas liquor effluent to the sewer should be under carefully specified conditions, and should be subject to payment in relation to the quantity and quality of the effluent. In this particular case, the Gas Company served a population three times as great as that served by the Sewage Disposal Works; in consequence the proportion of liquor to sewage was about three times the normal average.

The proposed conditions for admission were as follows:

(1) The volume discharged in any one day of 24 hours shall not exceed 2,200 gall.

(2) The volume discharged in any one hour from 6 a.m. to 10 p.m. shall not exceed 120 gall.

(3) The volume discharged in any one hour from 10 p.m. to 6 a.m. shall not exceed 60 gall.

(4) The composition of the gas liquor effluent at the point of measurement by the discharge recorded shall be subject to the following limitations:

(*a*) Oxygen absorbed from N/80 acid potassium permanganate in four hours at 26.7°C. shall not exceed 1,200 parts per 100,000 parts by weight.

(*b*) Free ammonia (calc. as NH_3) determined by simple boiling, without addition of alkali, and distillation into a standard solution of acid shall not exceed 40 parts per 100,000.

(*c*) Sulphide (calc. as S) shall not exceed 10 parts per 100,000.

(*d*) Suspended solid matter shall not exceed 6 parts per 100,000.

(*e*) The pH value shall not be less than 6 nor more than 10.

(*f*) Tar and tar oils not dissolved in the aqueous liquid shall not exceed 6 parts per 100,000.

(5) Temperature of the gas liquor effluent at the point of discharge shall not be higher than 110°F.

(6) The Ascot District Gas and Electricity Company shall pay to the Council 2s. 6d. per 1,000 gall. of gas liquor effluent discharged to the sewers.

(7) The conditions suggested in No. 8 of the model by-laws of the Ministry of Health for the reception of trade wastes into sewers.

It was suggested that the question of an Order from the Minister on the appeal should lie over so that the two sides might have an opportunity of coming to an amicable settlement on the lines suggested.

Following these suggestions the amount of sludge going to the digesting tank was reduced by approximately one-third on Nov. 1, 1940, thus increasing the capacity of the tanks by 50%. During November and December, 1940, 10,053 cu.ft. of sludge were sent to the digestors and 4.527 cu.ft. to the drying beds. At the same time pH measurements of the raw sludge, primary sludge and secondary sludge were made. The pH of the raw sludge varied between 5.4 and 6.7. At the end of 1940 the pH of the primary and secondary sludge was 6.7 and 6.9 respectively, and as they remained acid during the following three months liming was commenced. This process raised the pH of the primary and secondary sludge to about 7.0 and 7.15 respectively.

After May, 1941, no sludge was put direct to the drying beds, but all of it was passed to the digestor, as it was found that diverting sludge failed to produce alkaline digestion unless lime was used.

It was arranged that some of the spent liquor should enter the sewers at the end of June, 1941. The quantity allowed was 1,000 gallons per day or 0.24% of the sewage flow. With some interruptions the flow was gradually increased until at the end of the year the maximum quantity of 2,200 gallons per day had been reached.

Analyses made of the spent gas liquor are given below. The method of analysis was that given in the Alkali Inspectors' Reports (1919–1927).

The results are expressed in parts per 100,000.

Date	30.vi.41	7.vii.41	14.vii.41	11.viii.41	8.ix.41	3.xi.41
Time	12 noon	12 noon	12 noon	12 noon	12 noon	12 noon
Suspended solids	4	8	2.2	0.6	84	7.5
Free ammonia	14.5	12.5	10.2	20.2	34.4	82.1
Fixed ammonia	345	323	275	Not. det.	231	350
Sulphide	*Nil*	*Nil*	*Nil*	*Nil*	*Nil*	*Nil*
Oxygen absorption from N/80 permanganate (4 hrs. at 80°F.)	778	930	825	910	375	975
pH	7.5	7.0	7.1	7.5	7.6	8.1

The phenol in the spent gas liquor was 200 to 300 parts per 100,000, and the thiocyanate 30 to 50 parts per 100,000. Thiosulphate was 10 to 20 parts per 100,000.

The samples taken on Sept. 8 and Nov. 3 were abnormal. The September sample had high suspended solids and a weak oxygen absorption, which was due to solids from a spent gas liquor settling tank getting forward. The high free ammonia in the November sample was due to mechanical trouble with the concentrated liquor plant, which allowed some raw liquor to mix with the spent liquor.

* From a Paper published in the *Journal of the Institution of Sanitary Engineers*, July, 1943.

The spent liquor was admitted to the sewer at first only from 8 a.m. to 8 p.m. This period was later increased to 8 a.m. to 12 p.m. The following table shows the amount of liquor admitted to the sewer at various times:

Date.	Remarks.	Spent liquor gall./day.	Spent liquor as per cent. of sewage.
June 30, 1941 ...	Liquor admitted for first time since Feb. 1939	1,000	0.24
July 14, 1941 ...	Flow cut off for pump repairs, &c.	*Nil*	*Nil*
Aug. 2, 1941 ...	Flow resumed	1,200	0.26
Aug. 25, 1941 ...	Rate increased	1,600	0.4
Sept. 17, 1941 ...	Flow cut off for relining tank ...	*Nil*	*Nil*
Sept. 24, 1941 ...	Flow resumed	1,600	0.4
Oct. 23, 1941 ...	Rate increased	1,920	0.5
Jan. 3, 1942 ...	„ „	2,200	0.5

It was decided to use the rate of gas evolution as a measure of the activity of the sludge tanks. There is no gas collection at Whitmoor Bog, so it was arranged to measure the gas by partially immersing in the sludge a cylindrical tank of which the bottom had been cut away. An outlet pipe was fixed to the top of the tank and led to a small wet gas meter. Any gas which was evolved in the area covered by the bell had to pass through the gas meter, so that its volume was registered. One such apparatus was put in the primary tanks and another in the secondary tanks, but owing to transport and other wartime difficulties, it was not possible to start measuring the gas evolution from the primary tanks until August, 1941, and from the secondary tanks until November, 1941. Both tanks were about 4 ft. deep and covered an area of about 2 sq.ft. The meters were read daily and the volumes corrected to standard conditions (saturated gas at 60°F. and 30 in. Hg.) by calculation from the average air temperatures and barometric pressures. To get the total gas evolved from the tanks it was assumed that the gas evolution was proportional to the surface area. The metered volume of gas was, therefore, multiplied by the ratio of the total area of the tanks to the area covered by the bell. It was found by experiment that the gas evolution per unit area from two widely separated places in the primary tanks was approximately the same.

The volume of gas metered varied from about 2 to 15 cu.ft. per day. The resistance thrown by the meters was about ½ in. W.G. To prevent freezing in winter, the meters were filled with a 33% aqueous solution of glycerine.

Many analyses were made of the gas from both primary and secondary tanks. The analyses were made on the G.L.C. apparatus described by Gooderham (*J.S.C.I.*, 1938, **57**, 388–395), using his technique. The gases consisted of methane and carbon dioxide, with a small amount of nitrogen; hydrogen was absent. The percentage of carbon dioxide in the gas was found to vary somewhat. This variation was roughly correlated with the pH of the sludge, the percentage of carbon dioxide in the gas being higher the lower the pH of the sludge. Thus in the early summer of 1942, when owing to lack of lime the pH fell to 6.6 from about 7.0, the percentage of carbon dioxide rose to 32.2 % from 23.9%.

The gas analyses from both primary and secondary tanks are summarized below:

Primary Tanks.

	Aug., 1941.	Sept.-Nov., 1941.	Nov., 1941-April, 1942.	May-June, 1942.	Aug.-Dec., 1942.
No. of samples ...	2	8	8	2	3
Carbon dioxide ...	27.9	22.3	23.9	32.2	27.0
Methane	65.2	73.9	71.6	65.2	71.3
Nitrogen	6.9	3.8	4.5	2.6	1.7
Calorific value (B.Th.U. per cu.ft.)	649	735	712	649	709
pH of sludge ...	7.0	7.2	7.0	6.6	6.9

Secondary Tanks.

	Nov., 1941-April, 1942.	May-June, 1942.	Aug.-Sept., 1942.
No. of samples	8	2	2
Carbon dioxide	27.3	35.8	25.8
Methane	68.6	61.5	72.3
Nitrogen	4.1	2.7	1.9
Calorific value (B.Th.U. per cu.ft.)	683	612	719
pH of sludge	7.0	6.6	—

The calorific value of the gas was calculated from the composition. Methane has a calorific value of 995 B.Th.U. per cu.ft., saturated at 60°F. and 30 in. Hg pressure.

The gas was similar in composition to that found at other sewage works, and analyses of which have been published. It was, perhaps, rather richer in methane than the average, but this was probably due to the absorption of the carbon dioxide by lime.

Monthly results for the gas evolution from both tanks are given below. Owing to the variable absorption of carbon dioxide by the lime, it was considered that either the volume of methane or the thermal value of the gas was a better index of the activity of the tanks than the total volume.

The dosage of lime used during these experiments was about 56 lb./day, but varied somewhat owing to transport difficulties. The volume of methane produced per day in the primary tanks in August, 1941, was 3,420 cu.ft. In the succeeding months this diminished steadily until, in March and April, 1942, the methane was less than 600 cu.ft. per day. After this the volume rapidly increased until, in September, 1942, the methane evolved was 5,120 cu.ft. per day, or 50% higher than in August, 1941. With the advent of colder weather, gas production decreased in much the same way as in the previous year. It seems very probable that the rise and fall in gas production was due almost entirely to seasonal changes in temperature.

To raise 2,000 cu.ft. of sludge per week from the minimum of 35°F. to the maximum likely to be needed of 80°F. would need 56 therms per week. In September, 1942, at a sludge temperature of 58°F., the maximum temperature naturally attained, 350 therms per week were produced. While it is impossible accurately to calculate the heat losses by radiation and conduction from the digestors if they were heated, it appears that the sludge would provide ample self-produced fuel for heating. It is known that with similar plants there is a surplus available for pumping.

Conclusions

Owing to the fact that gas evolution from the sludge digestion tanks could not be measured for an extended period, when no spent gas liquor effluent was being admitted to the sewers, it is not possible to draw any rigid conclusions as to the danger or otherwise of this admission to sludge digestion. It seems evident, however, that in this case, while the flow of gas liquor was being properly controlled, no adverse effect on cold sludge digestion was produced.

With this particular unheated sludge, alkalinity of the digestion process was never attained, even when the capacity of the digestors was increased by 50% over their designed capacity.

Date.	Average temps. °F. Air.	Sludge.	*Primary tanks.* Total vol. cu.ft. per day.	Methane cu.ft. per day.	Cal. val. B.Th.U. per cu.ft.	Therms per day.	*Secondary tanks.* Total vol. cu.ft. per day.	Methane cu.ft. per day.	Cal. val. B.Th.U. per cu.ft.	Therms per day.
Aug., 1941 ...	58.5	—	5,220	3,420	649	34.0	—	—	—	—
Sept., 1941 ...	56.9	59.6	4,340	3,250	746	32.4	—	—	—	—
Oct., 1941 ...	48.2	54.3	4,060	2,940	719	29.2	—	—	—	—
Nov., 1941 ...	41.0	47.6	3,370	2,390	705	23.8	1,595	1,080	675	10.75
Dec., 1941 ...	38.7	44.8	3,060	2,185	710	21.8	1,510	1,040	685	10.3
Jan., 1942 ...	30.6	36.5	1,850	1,385	744	13.8	950	645	675	6.4
Feb., 1942 ...	30.1	35.0	1,080	780	716	7.75	535	377	704	3.75
Mar., 1942 ...	42.1	—	800	570	712	5.75	800	535	690	5.50
Apr., 1942 ...	47.3	—	830	590	708	5.9	1,215	810	663	8.05
May, 1942 ...	52.1	48.0	1,325	850	637	8.45	1,445	870	603	8.7
June, 1942 ...	59.4	53.5	2,380	1,582	662	15.75	1,710	1,065	620	10.6
July, 1942 ...	59.8	56.6	3,540	2,450	690	24.4	2,480	1,660	668	16.5
Aug., 1942 ...	61.6	57.4	5,360	3,860	717	38.4	2,600	1,870	716	18.6
Sept., 1942 ...	55.0	57.6	7,280	5,120	700	51.0	2,450	1,775	721	17.6
Oct., 1942 ...	48.6	55.3	6,730	4,770	705	47.4	1,475	1,030	694	10.2
Nov., 1942 ...	37.6	—	4,310	3,070	711	30.5	1,180	790	666	7.85
Dec., 1942 ...	40.4	—	3,110	2,220	711	22.1	980	628	638	6.2

Benzole Recovery by Active Carbon

In the "JOURNAL" of Sept. 15 (p. 337) we published a description of a modern active carbon benzole recovery plant by Mr. A. K. Howell, in which working results were compared with an oil-washing plant installed in 1932. It should be emphasized that the latter plant was designed for a 42% benzole recovery on a small make of gas, while the carbon plant was designed for full recovery on a larger make. It should not be inferred that the oil-washing plant did not give full satisfaction. Actually the results of its working were quite satisfactory.

The Montevideo Gas and Dry Dock Co., Ltd., announce the payment on Dec. 1 next of a dividend of 2%, free of income tax, on the Ordinary Capital of the Company, made up as follows—*Final:* 1% balance in respect of the year 1942 (making with the interim dividend of 1% paid on Dec. 1, 1942, and the partial final dividend of 2% paid on May 19, 1943, 4% free of income tax for the year 1942). *Interim:* 1% on account of the year ending Dec. 31, 1943, declared on Oct. 19.

WHERE DO WE GO FROM HERE?*

By ARTHUR FORSHAW, M.Sc.,

Chief Chemist, R. & A. Main, Ltd.

DURING the last year or two there has been considerable activity on what may be called the post-war appliance front. Thus a number of gentlemen have given us the benefit of their views, some, usually from inside the appliance industry, on what we may expect, and others, generally outside it, on what they are expecting; needless to say, these two ways of putting the matter describe or forecast results that are far from identical. This is perhaps inevitable where the protagonists vary from the enthusiastic booster to the more pessimistic individual who has to produce the goods. One writer envisages appliances "which are a vast improvement upon pre-war standards" (J. E. White, Institution of Gas Engineers Comm. No. 259); another remarks, "the domestic gas appliance is a head technically of that offered by either of the competing industries" ; and again "it is a little difficult in detail to anticipate the improvements which will be effected in the new designs" (H. Hartley, "GAS JOURNAL," May 12, 1943); while one speaker in a discussion hit the bullseye when he remarked that "in contemplating 'things to come' really nothing could be done at the present time because there was not the material to do it with" (J. B. Stewart, "GAS JOURNAL," April 28, 1943).

The fact is, of course, that the gas appliance makers, far from implementing, have for four years been actively reversing the Biblical prophecy about the turning of swords into ploughshares and have, instead, been putting their best efforts into turning from burners to bombs, and down the alphabet through grillers to grenades, to where the precision formerly associated with a "stat" has no doubt helped with a "sten," and the making of enamelled water heaters is replaced by that of enamelled water bottles. So much is this the case indeed that any organization which produces new and improved domestic gas appliances immediately after the war will be strongly suspect as to the totality of its effort during that unhappy though stirring period.

With these circumstances your invitation to address the Midland Association had its embarrassments. I finally decided, as the time when the normal supply of appliances and improvements is suspended is the best in which to take stock, to make an assessment of the present state of the art, and to determine what we may reasonably bear in mind as our aim when the Gas Industry eventually asks us, "Where do we go from here?"

With this object in mind, then, and starting with first things first, I must inevitably turn to gas cookers. For not only is this appliance the most important of all in itself, but it is in its design, construction, and performance that the biggest improvements have also been made during the time between the Great War and the Total War.

Up to this time the gas cooker had become more or less standardized, and the "improvements" which the various makers duly produced every year or two were in detail rather than in design. This is not to say they were all merely "sales points," for there is no doubt that the gradual introduction and popularity of loose for fixed burners, gas and air adjusters, enamelled linings and sides, or front for side gas rails, &c., did make for enhanced convenience and usability either for the gas undertaking or the housewife, or both; fundamentally, however, the cooker still consisted of an oven with two burners and a top flue and was furnished usually with loose gates or hangers, a grid or two, and that important *sine qua non*, the "browning shelf," while the hotplate had a number of different-sized ring burners irregularly spaced within a broad cornice or surround, which also contained a grill, the whole being surmounted by straight bars either of heavy cast or of lighter wrought iron.

After the Great War a period of great activity set in, and much work was done in the directions of promoting economy in gas used (thermal efficiency), improvement in quality of product (cooking effectiveness), and, not less important, in simplifying construction and promoting standardization.

The achievement of the first two of these was greatly facilitated by the publication in 1924 by The Institution of Gas Engineers of the first organized set of Tests for Gas Ovens. A revised set of tests based on these has recently been published by the B.S.I. after collaboration with both gas undertakings and appliance firms. This pamphlet B.S. No. 1115 is well worth the attention of those interested in oven design and performance.

The principal means of economy in the oven was the reintroduction of the bottom flue outlet, a device patented some 40 years before and afterwards completely forgotten. Its efficacy is due to the fact that a flue-outlet in this position automatically prevents, when the gas is reduced, an excessive throughpull of cold air, such as is the case with a fixed outlet at the top of the oven. While it has this advantage, the bottom flue-outlet brings several possible disadvantages nearer to realization. These are briefly smothering and condensation. The avoidance of these in various different physical surroundings is no doubt mainly accountable for the successive modifications in design which have characterized the principal makes of ovens utilizing the device, among which may be mentioned the "New World" of Radiation Ltd. and the "Conservor" of our make. A comparison of the original ovens bearing these names with their latest successors is an interesting exercise for the would-be designer and, to parody the Euclidean axiom, he would find things of the same name are not equal to one another. For instance, the "New World" started life with a side flue and a substantially equal temperature from top to bottom of the oven, without which last the thermostat was not expected to control the oven satisfactorily; it now has its flue outlet at the back and a "rice pudding" zone in the bottom third of the oven, while the "Conservor," which originally had horizontal flames (the then existing top-flued ovens could, in fact, be converted to "Conservor" by fitting a new back lining and inner crown plate), eventually had vertical flames protected by baffles to prevent smothering under severe conditions. Actually, although "Conservor" ovens are still at work in large numbers and could still be supplied were conditions normal, our latest ovens have relied on an improved principle—that of the "balanced flue." Here there are two sets of flue outlets, one at the bottom, which is capable of dealing with any anticipated gas consumption, however high, and a small one at the top, which can void the products of combustion of the gas required for the later stages of cooking, and that only after they have been forced to "back up" in the oven to a low level. Thus the whole of the oven is good cooking space and extraordinarily good and even cooking results are obtained, but smothering and condensation are prevented, while there is a "rice pudding" zone below the oven at drip-tin level.

Doubtless other makers of bottom-flued ovens have gone through similar cycles of modification and development.

In making these remarks on the design and performance of modern gas ovens I am deliberately confining myself to facts, and so I do not venture into the controversial regions where single and double burner ovens advertise their own virtues and, by implication, their rivals' defects. Suffice it to say, that to the searcher after truth the argument is largely fictitious—it is not the number of burners that is of major importance but the cooking results, and experience and research alike show that whichever form of heating is adopted the results can be varied by altering the design of the other parts of the oven, such as the positions of the burner and the flue outlet both in relation to the oven and to each other. Thus, as is implicit in the above remarks, single-burner ovens can be made with or without included rice pudding zones, and if it be considered necessary or desirable, the same sort of differences can be produced in ovens using two burners. The hollowness of much of this "stage fury" is exposed when we know that protagonists of single-burner ovens continue to make two-burner ovens, and supporters of two-burner ovens are willing to make you single-burner ovens if you insist.

The state of the art, then, is that in the leading makes of oven the latest models show some remarkably good cooking results. If you examine a tray of scones or small cakes from such an oven it is difficult to find any inequality in browning or finish. On comparing one tray with another you find usually that the higher in the oven the sooner the trayful is ready, and it is in such differences that a distinction may be made between one make and another; obviously in an included rice-pudding-zone oven there comes a level, as you go down the oven, below which cakes will not bake nor meat cook. Some users clearly prefer such an arrangement or sales would not continue; others as clearly favour an oven for which we were able to use the slogan "it bakes on every shelf," and full loads of, say, bread can be cooked with the least rearrangement. Other features distinguishing the products of cooking are the balance of sole heat and top heat. If, however, the designer knows what particular result is required he can produce it. In the absence of detailed requirements he must "chance his arm" on what will suit the majority, hence the differences without which stereotyped appliances only would be available, improvements would be difficult or impossible and progress strangled.

Summing up, then, I think we can say that the gas appliance industry in its best examples has available ovens which give, for a comparatively small requirement of gas, exceedingly well-cooked food-stuffs of all sorts—they are, in fact, both efficient and effective. Standardization of construction is, however, another matter, and however simple the method used by each maker, it is bound, under present conditions, to be different from that of his competitors. Even were it conceivable that a standard construction would be accepted by all makers, the difficulties of real interchangeability of parts would still be very great. Suppose, however, that, great as they might be, such difficulties had been overcome and all makers were supplying a truly standard oven, what a tremendous matter it would be to introduce any modification or improvement, and what a numbing effect the realization of this would have on research on the further improvement of the breed.

The net outcome of all these considerations seems to me to be that standardization can only be hoped for in gas ovens to the extent on which a "highest common factor" can be agreed between makers. If and when that has been achieved the Gas Industry will no doubt be presented with something in the nature of a compromise which it will

* Paper to the Midland Association of Gas Engineers and Managers, Oct. 21.

have to accept for a considerable time—that is, until a certain minimum output has been produced and absorbed, otherwise the benefits for which it is seeking (*viz.*, quantity production of a standardized article at as reasonable a price as possible) will not be realized. If all we are told about the tremendous shortage of gas cookers is borne out in due course—that is, the ordinary statistical yearly demand plus the replacement demand plus the furnishing of new property demand—it seems to me that a sound "compromise" cooker without gadgets, embodying the best agreed-on features to date and with the minimum of mere selling points, will not only be the quickest way of helping the housewife and the Gas Industry, but also the appliance firms. It will, for instance, provide sufficient output for them all to see their initial expenditure on plant covered and thereafter a reasonable profit earned.

The experiences of the years before the war showed that modern designs employing stamping, where the traditional material had been cast or wrought iron, required a much greater expenditure on tools and plant and a correspondingly greater absorption of output before profits began to accrue. In fact those of the appliance makers who had the opportunity to adopt such mass-production methods realized one reason why American cookers are so costly in that country, where improvements and alterations must apparently be introduced at comparatively short intervals to satisfy a public jaded with the continued efforts of high-power salesmanship. In these circumstances the makers never have on one particular model an uninterrupted run of output prolonged enough to ensure that the benefits of mass production came within reach of "the consumer."

The corollary to this argument is that those who prefer "the little something others haven't got" will, after the war, either have to wait some time for their fancy, or to pay fairly heavily for it, or both, and all this with the best will in the world on the part of the makers to get back to that particular market.

It will be noticed that I have so far mostly used the word "oven" and only latterly the more comprehensive "cooker." I have deliberately done this because standardization of hotplates on an interchangeability basis is still more difficult than that of ovens; in fact I think it is generally realized that whilst the makers may achieve a "standardized" cooker on the lines already discussed, "interchangeability" cannot be expected either in oven or hotplate. I would not like to be thought to be apologizing to the Gas Industry for holding this opinion. After all that has been written and spoken in the last few years on this subject of standardization, perhaps there are some who feel that it is time the appliance makers either put up or shut up; to those I would gently breathe the words "calorific" value and "sulphur removal," on which possibly they will realize that all desirable ends are not easily implemented on either side of the larger Industry.

The standardized cooker, then, must of necessity embody compromises, and it cannot afford to make experiments. Any improvements, "vast" or otherwise, must be first tried out in another class of cooker where the price allows of more margin for eventualities. When they have made good, their novel features can gradually be brought into the less expensive ranges.

In this connexion, and after a long experience, I think it is legitimate to wonder whether half the advantages at which technical staffs have sweated to provide salesman with something new are ever really appreciated by the user and operated intelligently. One simple thing occurs to me as an example. We work for months on improving the performance of a hotplate boiling burner, size of injector, shape of venturi, size and angle of flames coupled with shape and disposition of supports for the kettle, result in the lab., say, 50% thermal efficiency; in the kitchen the good lady puts the kettle on eccentric to the burner (cockeyed if you prefer the term)—result ten units in the percentage lost and the kettle handle so hot that it cannot be lifted by the bare hand. Again, in spite of 20 years of intensive pushing of oven thermostats, correspondence and visits alike show that a proportion of users do not understand their purpose and possibilities and never will.

Even technical staffs have simple problems apparently still unsolved: where, for instance, should a "simmering" burner be placed, at the back or the front of the hotplate? This is a problem with only two possible solutions, but there is always a good argument put up *afterwards* for the one you didn't adopt, and you will find examples of both methods in use. With such points in mind is it to be wondered at if the highest common factor of agreement between makers of hotplates should be so many square inches of hotplate and so many burners with a maximum total consumption, and after that go as you please.

There is a movement in favour of the more widespread substitution of luminous-flame burners for bunsen burners in gas appliances of all sorts. I think it has recently been pointed out that this, so far as ovens are concerned, is a return to a former practice. I have taken the trouble to look into this, and I find that we still have in one "museum" one or two survivals of an oven with which my firm won a medal at what was then a big cooker exhibition and practical test at the Crystal Palace in 1882. The firm then attributed their success in meat roasting to the use of luminous-flame burners, presumably against bunsen burners. They afterwards put forward a logical explanation of the difference these made to the quality of the roast. Very interesting. But why did they drop an advantage apparently so well proved both practically and theoretically? Frankly, I don't know, but I would point out that as luminous-flame burners usually burn, jet for jet, more gas from a much smaller orifice than do bunsen flames, an oven so heated would contain, for the same gas rate, many fewer jets, and that a spot of grease could block one jet and so entirely put out of action a significant proportion of the total consumption, thus possibly upsetting the balance of the oven, while with a blocked bunsen hole the gas is not stopped but merely distributed over the remaining holes. Doubtless this could be forestalled by putting burners in a separate compartment outside the oven chamber; but this would probably reduce efficiency or effectiveness, or introduce some other disadvantage, such as comparative inaccessibility for lighting or cleaning. Be that as it may, the revival of luminous flames for oven heating may rest on something definitely advantageous to the Industry and the user. Let us hope so, and that such an alteration is not proposed merely for the sake of "novelty." One advantage that does suggest itself is, of course, the greater suitability of luminous flames for use with a thermostat because they may be reduced without the possibility of "lighting back," and another is the increased percentage of radiant heat where the flames are really luminous. The same argument applies to hotplate burners, and while one can hardly see a satisfactory luminous-flame griller on present lines—that is, if the flames really are "luminous" enough to deposit carbon when in contact with solid material—experiments with boiling burners so furnished show some promise, while for solid hotplate heating they have long been adopted.

In general one can definitely say that the removal of luminous-flame burners for cleaning can never be so easy to ensure as it is at present with bunsen burners which, either in the oven or on the hotplate, may now be merely lifted out, while with luminous flames some form of gas-tight joint would have to be broken before withdrawal—an exercise that gas engineers would probably prefer that consumers refrained from attempting, while the picture of the cook trying to clear a stoppage in the steatite teat with the prong of a fork gives one a shudder. I would remind you, further, that however promising any of these applications of the luminous flame to cooker work may appear, there is only one valid test of its suitability, and that is the practical test of a sufficient number out on the district in the hands of and at the "tender mercy" of the consumer. Until that test is satisfactorily withstood for, say, two years, success, however searching the laboratory tests, cannot be assured.

Before leaving cookers, I should like to refer briefly to the matter of oven control. I have been asked several times lately whether as satisfactory results could be obtained by using a graduated cock in place of a thermostat. Some 15 years ago, in a booklet I wrote on cooker construction,* I gave a comparison of the effects to be expected from these contrasted methods of control. So far as I know this still holds good, and I do not propose to repeat it here. I would, however, say that no manual control, however painstaking and sustained, can ensure the exactitude of performance that characterizes a thermostat, either in temperature response, reproducible cooking results, or economy of gas. Much as the "cooking is an art" people may deplore it, the gas appliance industry, stimulated by the pioneering work done in America with oven thermostats, has been striving for 20 years to make cooking more scientific—that is, more fool-proof—and, largely with the aid of the thermostat, it has had a considerable measure of success, resulting in a general improvement in the standard of cooking. Reverting to tap control would be a retrograde step, and would probably result in an increased number of complaints and maintenance visits and costs. So far as my experience goes the oven thermostat is remarkably free from trouble, and I think no one with a knowledge of tap construction and lubrication would expect a tap, graduated as it must be from, say, 5 cu.ft. to 30 cu.ft., to continue to give a trouble-free performance at all comparable.

We now pass on to consider water heaters. Of all the domestic appliances, cookers, as I have already remarked, are the most important both actually and potentially because, of course, in the natural requirements of mankind food and its preparation take first place, and in the last resort man can survive lack of artificial heat and lack of cleanliness for much longer periods, if not indefinitely, than he can lack of food. His next most important requirement is protection from cold, and while the production of artificial heat, whether from solid or other fuels, becomes more and more important as the local climate becomes more rigorous, a deficiency in it can to some extent be made good by conserving bodily heat by the use of extra clothing. The modern tendency, of course, to tip the balance in the opposite direction for the use of lighter clothing, particularly among women, forces the householder to make up for it by ensuring more artificial heat. Space heating, however, is so important that practically every existing house has provision for it in all but the smallest rooms without reference to gas, whereas it is doubtful whether the amount of hot water now considered necessary is capable of production by the similarly existing installations of the usual type. The fact, of course, is that while space-heating requirements have grown, the existing means can often be made to deal with them, although perhaps inconveniently without recourse to gas, whereas the requirements for hot water, both actual and potential, often cannot be so met. On this basis and *assuming* a minimum requirement of hot water per person or per household, the experts amuse themselves in statistical exercises leading to opportunities to dispose of gas-heated hot water appliances running into millions. Whether we can rely on the figures thus arrived at or

* *A Standardized System of Cooker Construction.* R. & A. Main, Ltd.

not, there is no doubt that the number of appliances *required* after the war will be very great. Whether they will actually be *acquired* in anything approaching the astronomical quantities of the experts depends on a number of factors, an important one of which is that the public shall then find itself left with the means, not only to pay for them, but also to continue to use them.

However, suppose we rank ourselves with the optimists and assume that a substantial demand for water heating by gas will have to be met; the question then to be answered is what types of appliance must be looked to for the service.

It is precisely here that we reach controversial ground. There are those who have no hesitation in putting forward their own particular "unilateral" solution of the problem, to the exclusion of any other. They have laid themselves out each to produce one particular type of heater and, perhaps naturally, are prepared to use all means in their power to ensure its adoption in all situations and to advocate and defend it through thick and thin. So far, I may point out, none of these has succeeded in monopolizing the hot water business.

Let us, however, spend a few minutes in considering some of the alternatives available for producing gas-heated water, and perhaps I had better make clear at once that as my firm are makers of a large variety of different appliances, including the instantaneous, I can, I hope, speak without the bias naturally to be looked for in the protagonist of one type of heater only. This is not the place nor have we the time now to make an exhaustive enquiry into all the possible forms that gas-heated water appliances may take and our survey must therefore be eclectic.

It was formerly possible to divide heaters into significant distinguishing categories by putting on the one hand those, such as geysers, for use independently of any existing installation, and, on the other, those like circulators for attachment, either as principal or as auxiliary to an existing house system. Developments and improvements have eventually tended to blur this dividing line, and it is no longer a clear-cut one, for "instantaneous" heaters can be attached to circulating systems, and "circulators" with their own storage used independently of existing piping systems. In trying therefore to find the appliance best suited to meet the requirement of any particular case, we have to-day a more difficult task than when there were in effect only two alternatives, but, with the wealth of diverse appliances available, we have the possibility of finding among them one which will be more nearly suited to deal with all the factors involved, and so to give more satisfactory service than would have formerly been the case. As already indicated, I cannot now attempt any exhaustive and detailed consideration of all the heaters available, and must confine myself to a short discussion of the contrasted characteristics of two typical heaters—*viz.*, the instantaneous and the storage.

The fundamental difference between these types is, of course, that of input. For any particular requirement of water the "instantaneous" type uses many more times the gas rate of the corresponding storage type, simply because it tries to live up to its name as to time of delivery. Actually it never succeeds, but the nearer it gets to instantaneity of delivery the more gas it must burn and the larger it has to be, with the corollary that the shorter will also be its period of use until we have in the large instantaneous heater a possible output approaching one therm of hot water *per hour* against an estimated requirement for the average consumer with a family of four of from 50 to 200 therms *per annum* according to income group. You then have the paradoxical situation that you have sold this consumer an appliance on the grounds that it is highly efficient, has comparatively small standby losses and is capable of delivering "unlimited" hot water, *but* that, of course, he must rigorously restrict its use because if he doesn't he will rapidly go bankrupt.

It is to this that the policy of refusing to recommend anything but the instantaneous type of heater logically leads. Anything of this type of smaller input than about 0·75 therm per hour will, on the other hand, bring complaint of slowness in filling a bath. In winter time particularly, when the bath and the bathroom as well as the bath water all usually get their heat from the appliance, this is fatal to the consumer's goodwill towards gas.

So far in considering this matter I have confined myself to the consumer's point of view, and while that is of the greatest importance there is also, of course, the point of view of the gas undertaking. If the policy is to be one of recommending instantaneous heaters in all circumstances, the undertaking must usually be prepared for a considerable outlay on increasing the facilities for the supply of gas, for it has to envisage the possible use of all the heaters at approximately the same time, thus giving rise to a peak load, such as all public utility providers are doing their best to avoid or to reduce. It is true that the storage of energy in the form of gas does not entail any new departure and, as most of us may well admit, the Gas Industry is thus favoured by fortune, but the utilization of the stored energy in large simultaneous dollops may well require the provision of larger mains and service pipes and, in the consumers' premises, of larger meters and piping.

In spite of the comparatively short time during which the large instantaneous heater has been pushed for exclusive universal use in this country, there is a certain amount of evidence that both of the disadvantages just mentioned—*viz.*, consumers outrunning their means because of the "unlimited" hot water available, and of undertakings realizing the disadvantages of building up peak loads—have forced themselves into recognition.

One other possible source of trouble does not seem to me to have had factual elucidation adequate enough to allow of firm estimates. I refer, of course, to expenditure on repairs and replacements. Until sufficient experience has accumulated over an extended period embracing all seasons, the commitments likely to be undertaken under these heads are bound to be guesswork. If the makers of the large instantaneous heater should reply that they have available maintenance figures collected over many years, I should point out that domestic conditions in Britain are very different from those in Central Europe, as was shown in the casualties among these heaters in this country during the severe winters following the outbreak of war. Quite frankly, we ourselves have given this side of the matter very considerable attention, our research work resulting, so far as we can as yet ascertain, in a longer working period without the necessity of servicing, and probably in much less actual work being required when servicing is necessary—(you see how cautious I am)—compared with competitive appliances.

While on this part of the subject I should like to say that, as no doubt you are aware, unless something abnormal occurs, one of the biggest factors in causing the necessity for maintenance in water heaters, and in instantaneous ones in particular, is the presence of sulphur in the gas, and that for reasons I have gone into at some length on another occasion ("GAS JOURNAL," Feb. 18, 1942). If the Gas Industry can manage to implement the oft-expressed intention of doing away with sulphur or at least reducing it to a really negligible amount, it will immediately find the benefit in reduced maintenance for all appliances, but as I said before, particularly for water heaters of the instantaneous type.

I hope I shall not be accused of being unduly pessimistic about the large instantaneous heater, for, as I have already indicated, we ourselves are interested in marketing our own pattern and we are naturally wishful for its success, but we do feel that the indiscriminate boosting of it, or for that matter of any one appliance, for all water heating purposes, would not in the long run conduce to that success, and that is why I have made my previous remarks and indicated where I think caution is necessary. There are, of course, many other situations in which its particular features make it an excellent proposition, both for the consumer and for the undertaking, and we are looking for very considerable business in it when normal times return. For those situations where some other type is preferable I suggest that the choice is still quite wide, for there are circulators, either auxiliary to existing systems or superseding the heating means on an existing system, and in addition circulators with their own storage. There are also storage heaters for attachment to existing systems and self-contained storage heaters.

It may, however, be instructive to compare shortly the performance of a multipoint instantaneous heater with that of a storage heater, for which purpose I take our No. M.1 Multipoint and our No. 14 Thermain.

The former burns one therm per hour (200 cu.ft. at 500 B.Th.U.), and with this input can supply, indefinitely, water heated through 40° F. at the rate of 3¼ gall. per minute or its equivalent up to a rise of 85°F., at which the rate of output is 1½ gall. per minute. It can be fitted to supply any point in the house, above or below itself, provided there is sufficient head of water to operate the gas valve and ensure the required flow. It is usually fitted in the scullery, because this means the shortest length of pipe to the most-used point, and therefore the least loss from dead water in the connecting pipes. It requires an effective supply of gas to connect to its 1 in. gas inlet. It also requires a large and effective flue to the outside, because the products of combustion of such a consumption of gas are so great in volume that although of themselves non-toxic, unless removed effectively they might rapidly cause conditions dangerous to life.

The storage, on the other hand, burns $\frac{1}{10}$th therm, or 20 cu.ft./hour, during heating-up. It contains 14 gall. of water, which attains 140/150°F. in 2 hours from cold. It has a self-contained ball-valve tank, and can therefore be used only for draw-off points below its own level. In practice this means it is fitted in the bathroom, where it supplies to the bath and lavatory basin and, through the floor, to the scullery below. It should be fitted with a flue to avoid condensation and its consequent troubles, and not because of any danger to life, which is at the worst very remote at such a consumption. Unlike the usual type of thermostat, which cuts down the gas gradually as the water heats up and so prolongs the heating-up period unduly, the "stat" on this particular heater has been specially designed to keep the gas full-on until the maintenance temperature is reached, thus shortening the heating-up and recovery times. After heating-up has finished, the supply in the ball tank gradually warms up, thus further shortening the recovery time necessary after the withdrawal of all or part of the original hot storage. With 10 gall. of cold water at 50°F. mixed with 14 gall. of hot water at 150°F. (that is, after the heating-up period is completed) one gets a bath of 24 gall. at approximately 108°F.

If the full storage is thus utilized another bath cannot be obtained until at least 2 hours have elapsed, but, clearly, even if the consumer continues to draw a bath every two hours, the total gas used cannot exceed 1 therm, or 200 cu.ft., in 10 hours—that is, equal to the gas burned by the instantaneous heater in one hour's continuous use.

The advantage of such an appliance in preventing the consumer in the lower ranges of income from overrunning his financial possibilities is very marked, and if we look for anything in the instantaneous class

to compete with it in this respect we find we are disappointed. The smaller types, like sink-heaters, while no doubt admirable in their own way for small spot-heating jobs like washing-up, do not allow of use for providing baths because they cannot give the output; even the biggest of them can hardly provide bath water at the rate of a gallon per minute, which is not fast enough, while many of them are still slower. A further objection against any attempt to use a sink-heater in this manner is, of course, the heavy wear and tear to which it would be exposed and the consequent expectation of short life.

I have no time to go into details of performance of other appliances such as high-consumption storage heaters, or of circulators as principals or auxiliaries; they all have the uses to which they are particularly adapted. I will, however, remind you of one curious fact, which is that although one might expect from its name that the instantaneous type would give a definite quantity of water in a quicker time than any other type, in practice this is not so, for the rate of delivery of hot water from a storage system, up to its actual capacity of course, is only limited by the size of piping and taps and the pressure available, whereas that of the instantaneous is further limited by the size of the heater, and ultimately by the rate at which gas can be effectively burned in it.

The word "instantaneous" in this connexion refers, of course, not to the time of delivery but to the apparent effect—*viz.*, that the water is instantaneously heated from cold to the temperature of delivery. It is perhaps as well to remind ourselves of facts of this sort lest we unconsciously convey to others an erroneous impression of the function of the appliance we may happen to be discussing.

The task of discriminating between all the types of heater either mentioned or available, and of selecting the best for the immediate purpose, clearly calls for experience and for a discussion of each case on its merits; but surely it is better to go through this preliminary and, as I think, necessary consideration, troublesome though it may appear, and therefore to be in a position to recommend something with confidence, than to risk future disappointment and disillusionment by adopting the ready-made policy of one sort of appliance only, be it instantaneous, or storage, and by automatically recommending it whatever the situation and circumstances of the consumer. It will be realized that in order to be able to give this consideration and to recommend the best machine, that is, the one which is likely to give the particular user the most advantageous service for his needs, the salesman should not only have a sufficient knowledge of water heating in general and of gas-heated appliances in particular, but should be free to recommend and supply any type which his knowledge leads him to regard as the most suitable for the particular job.

And now at last I come to space heating, more particularly for domestic purposes. Its importance I have already touched on. Personally my work has been much concerned with this side of the appliance industry since I entered it over 30 years ago. At that time the first great move forward had just started away from the deep "skull"-filled fires towards the shallow high-radiant-efficiency fires which gradually took their place. This necessarily short *résumé* cannot go into detail and a lot must be taken for granted, but who can deny that the then wholesome reaction against the high-temperature convection and smelly stuffiness that characterized the deep fire has now been carried too far. The majority of modern radiant fires, owing to their plain design and the method of fixing directly into a house chimney, and the large flue outlets which are necessary to make them pass the *Lancet* test, nearly always lose far too much expensive heat up that chimney in the flue gases and in the unnecessarily large quantity of air removed by flue suction. I say unnecessarily large because owing to the position of the flue outlet this air is really withdrawn mainly from the lower parts of the room, which is, therefore, over ventilated compared with the upper parts. The realization of this fact is no doubt responsible for the movement in favour of recommending either radiant fires supplemented by the so-called "background" heaters, or by radiant fires provided with their own integral convecting devices. Such combinations, and particularly the first, are economical, not only because they utilize in the form of convected heat energy which would otherwise escape without doing useful work, but also because the warming of the air in this way makes a room comfortable in a much quicker time than where the source of heat is producing nothing but radiation. The reason is, of course, that radiation has no direct warming action on the air, and that until sufficient has been produced and absorbed by the walls and furniture to allow of them imparting heat secondarily to the air, the human body is chilled by contact with the cold air, and also because it is itself radiating to the cold surroundings. Only those parts of the person directly exposed to the radiant fire obtain any sensation of warmth, whilst any attempt to increase this effect by getting nearer to the fire is eventually followed by the unpleasant burning sensations due to the absorption, by the skin, of more of the long infra-red rays which constitute the main heat output of all radiant fires than it can conveniently pass on to the body beneath. Furthermore, reading a newspaper or any other occupation likely to interfere with the access of radiant heat to the skin, which, of course, means usually only the face and hands, immediately causes discomfort. "Background" heating prevents these drawbacks by rapidly warming the air and causing it to circulate.

After a very short while even the remote parts of the room become habitable, and the usual high concentration of occupants round the fender made unnecessary.

I should not like this argument to be stretched too far, and the conclusion drawn that I am advocating convection *instead* of radiation as the ideal space-heating medium. I am still a believer in radiation as the main source of heat for living apartments, but where suitably supplemented by convection it is more comfortable during the initial period of heating, and the combination provides heat at a reduced cost.

(To be continued)

RATIONAL PREPARATION OF COAL

The following is a report of the discussion on the Paper by Dr. R. Lessing at a meeting of the Institute of Fuel on Sept. 30—see "JOURNAL of Oct. 6 and 13. Lord Hyndley, G.B.E., Controller-General, Ministry of Fuel and Power, presided for the first part of the meeting and Dr. E. W. Smith, C.B.E., for the latter part.

Lord **Hyndley,** introducing the Author, said they would all agree that the preparation of coal was a very important subject. Some might think that the Paper was advanced in its ideas, but he was certain of this—that every question connected with preparation of coal should be most thoroughly examined.

Dr. **J. G. King** (Director, Gas Research Board) said Dr. Lessing would be the first to admit that his plan for the organization of coal preparation after the war was not a new concept, but rather a comprehensive scheme to put on a national foundation the best of the methods of coal treatment which the coal industry had been developing for so many years. He would also agree that very considerable strides had been made by the industry up to 1939, when one considered that 40 to 50% of the coal mined was being dealt with by some form of cleaning process. Much of this advance was frozen by the advent of war conditions, when transport became the over-riding factor and efficiency of cleaning became secondary to high output. One might agree, therefore, that the present was a suitable time to review what had been done in the past, and to make a new and more comprehensive plan such as that which Dr. Lessing visualized for future administration. That plan must obviously make use of the lessons of the past, take into account new considerations, and formulate a scheme which would ensure the adequate cleaning and sizing of all coals, and which would make available for each industry those grades which its own special requirements demanded if it was to maintain that high level of efficiency which would be necessary after the war. There were new ideas in the Paper which required study. It could be admitted that the removal of dust before cleaning would greatly help washing processes, but was it a practicable proposition to postulate the drying of coal when this meant expenditure of fuel? In order to answer that question it was necessary to balance this fuel requirement against considerations of power consumption, increase of output and possible increase of efficiency in secondary processes.

Perhaps Dr. Lessing could say what proportion of British coal would require drying, either because it came from a wet pit, or because of our treacherous climate, and, if drying were imposed, what would be the increases possible in the output of the washery, the efficiency of separation, the saving in the cost of dealing with the slurry, &c. An adequate review of all these factors would lead to a clearer picture. There were minor points which also required consideration. One could accept a theory which abolished the archaic picking belt, but the removal of dust and its efficient utilization was not so easy. The dust formed by the first screening of lump coal might be rich in fusain, but it did not contain all the fusain in the coal, since fusain occurred in thin bands and breakage after screening would liberate more; also the figure of 2·5% indicated in Table VI of the Paper was low, since bands below ¼ in. were not included in this survey. The amount of dust to be utilized as such would therefore be more than the 8 to 10 million tons suggested. The utilization of this dust would postulate a considerable advance in, say, pulverized fuel firing. This might, however, be the right aim. A second point was the separation of bright coal (75%) into more than one fraction in order that those industries to which caking power was important should have a wider choice in respect of this important factor. The Author had drawn a favourable picture of this, but one must not lose sight of the fact that coals varied in rank, and that it would not be possible in every area to separate fractions which would vary sufficiently in their caking powers to justify the expense of separation. If, however, the proposed scheme were introduced one might imagine a post-war coal industry in which all coal was cleaned and separated into sizes and grades, each of which could be characterized by a specification which included not only the old factors of size and ash content, but in addition volatile matter, caking power, fusion temperature of ash, and perhaps even others. These factors would cover most industrial requirements, and special processes could look after themselves. If such a perfect state of affairs came about, the consumer could have a wide choice and would be limited only by such considerations as cost of transport; also if policy decided that we were to have an export market after the war, such an exact characterization would appeal very much to foreign buyers.

Some doubt was expressed as to whether every appliance could handle very clean coal efficiently (*e.g.*, the chain grate stoker). He

supported Dr. Lessing, and suggested that the engineer would overcome any difficulties associated with low ash content with more pleasure than he did those associated with high ash content, with more rectitude than when he found means, say, of making Durham coking coal burn efficiently on a Lancashire boiler grate. The Author gave a remarkable example of the far-reaching effect which could result from the use of cleaner and more carefully sized coal in the Gas Industry. Not only did the cleaning improve the efficiency of the treatment of the coal in the primary process of carbonization, but it had secondary effects in appreciably improving the quality of the products. The removal of mineral matter from coal dust, in a carbonization process, improved both the yield of gas per ton of coal and the output of gas per unit of time in proportion to the mineral matter removed. If dust removal also meant a lower free moisture content the improvement was still greater.

In this example the improvement in ash content would mean an increase in output of about 7%, but the improvement in moisture content was negative. Unfortunately the actual increases of yield or output were not quoted either in Dr. Lessing's Paper or in Colonel H. C. Smith's Paper. If they were available he suggested they might appear in the Author's reply. It would be interesting to know if they were in proportion or greater. The improvement in the coke was very marked, and was reflected not only in its direct use as a fuel, but in its performance in a water gas plant. The improvement in yield was again not disclosed, but the gain in output was 22%. Some 3·5 of this was due to the reduction of time spent on clinkering and 4.8 to reduction of ash, so that there was a 14% improvement in rate of gasification over and above the improvement calculated arithmetically. These results might be rather flattering to "clean coal," since the amount of coal dealt with was not large and the plant might not have settled down, but they did serve as an example of the fact that the Gas Industry would, after the war, want not only clean coal, but coal having specific and repeatable properties. For its present technique of carbonization it already required a certain range of size and caking power for the horizontal retort, a different range for the chamber oven, and a still different range for the continuous vertical retort. For all of them it wanted low ash and moisture contents. For its future requirements it would certainly want all those and also a closer definition of caking power for new processes such as complete gasification, and gasification in hydrogen under pressure. It might also want special coals for making reactive cokes for domestic use and for mobile gas producers. If a scheme such as that visualized by Dr. Lessing would provide that wide choice, with close definition of caking power, the Gas Industry would certainly support it.

Dr. **A. Parker** (Director of Fuel Research) said everyone would agree with the general theme of Dr. Lessing's Paper, which drew attention to the need for improvement in the methods of preparation of coal for the market. As Dr. Lessing had pointed out, their coal reserves were not unlimited, particularly the reserves of coals of special qualities such as coking coals, and it was important to ensure that the coal reserves were utilized in the best national interest from a long-term point of view, and that so far as was practicable consumers were supplied with those grades and types most suited to their requirements. On considering how those objects were to be achieved it was soon realized that many problems had to be solved and difficulties overcome. Those problems and difficulties largely arose from the fact that the accessibility and character of the coals in the various coalfields and even in different parts of the same coalfield differed considerably. They arose from what might be termed the heterogeneity of the industry. Coals as they existed in the mine varied in type from lignitous on the one hand to anthracitic on the other, and there were marked differences in the nature of the associated rock, in the inherent moisture, and in other properties. These differences were the cause of a variety of problems in the collieries, not only in the winning of the coal, but also in the subsequent preparation for the market. In addition there were restrictions imposed by different market conditions, and the requirements to be met in the use of coal for many different purposes. In consequence, several different methods of coal preparation had been developed, each of which was no doubt considered in some quarters to be well suited to the particular contitions under which it operated.

In some respects the system which had grown up had given satisfaction in meeting many of the varied demands. In other respects the results had not been entirely satisfactory. It was known that there were coal preparation plants which were inefficient, and it could not be said that the allocation of coals of certain types for specific requirements had been all that was desirable from the broad national point of view. In an attempt to solve the problems associated with the future development of the industry, Dr. Lessing had drawn upon his long and intimate experience of the subject, and the result was a definite scheme advocated in his Paper. This scheme clearly merited close examination. As he understood Dr. Lessing's scheme, he proposed that all coal after being brought from the mine should be crushed to below the size of about 4 in.; it should then be de-dusted, treated for the removal of ash so far as was possible, and for classification into bright and dull coal, and finally size-graded. In his own view it was doubtful whether it would be practicable and economic to apply all these processes to all coal from every colliery in the country, or even to a large proportion of the coal. There was undoubtedly room for an increase in the practice of crushing and de-dusting coal, but it was by no means certain that there would be an overall net advantage in treating all coal in that manner. Crushing must lead to the production of a larger proportion of fines which, except in limited quantities, were likely to present more difficulties in transport and utilization than the larger sizes of coal.

The proposed separation of bright and dull coal seemed to him also to be subject to many difficulties. In the first place, the difference in the specific gravity of the two types was often very small, and there might even be no appreciable difference in some cases. Secondly, the effective specific gravity of the coal was influenced by absorption by the bright and dull coal of different proportions of the flotation medium. With low rank coals the amount of liquid absorbed might be 15% or more of the weight of the coal. Thirdly, the tendency for bright coal to be more strongly caking than dull coal was not generally so marked as Dr. Lessing had indicated. For example, the bright coals from Leicestershire and South Derbyshire, and from certain other areas where the coals were of low rank, were almost devoid of caking properties.

The Paper made out a strong case for the efficient cleaning of coal, and that plea would be generally welcomed. There were, however, some instances in which the use of coal not previously submitted to cleaning processes was justifiable. According to the figures given, the cost at the pit of equivalent weights of coal was increased by approximately 15% as the result of the cleaning processes. As Dr. Lessing and others had preciously pointed out, the expense of these cleaning processes was frequently more than counterbalanced by the greater economy in the subsequent use of the coal. As an example, some data were given with the object of showing the advantages of using coke prepared from clean coal in the manufacture of carburetted water gas. Though he agreed with the general conclusion that coke low in ash must have advantages in comparison with coke containing a large quantity of ash in the manufacture of water gas, he hesitated to accept that some of the differences in the two columns of figures in Table IV of the Paper were attributable mainly to the difference in the two cokes employed. There would seem to have been some important difference in the cycle of operations in the two tests, as indicated by the figures for the amounts of steam used per 1,000 cu.ft. of gas. In any case he would prefer to describe these two cokes as clean, and exceptionally clean. The coke from the coal which had not been cleaned contained only about 8% of ash, which was equivalent to only about 5½% in the original coal. Many operators of water gas plants would be more than delighted if they could ensure that the coke they used never contained more than 8% of ash.

Viewing Dr. Lessing's proposals as a whole, there was no doubt that he had made a real contribution to this important and difficult subject. It would be somewhat revolutionary to apply his scheme within a short time to the whole industry, and he suggested that development on the lines indicated should proceed gradually on the basis of the accumulated results of practical experience. Only on the basis of such experience could the advantages and, in some cases, possibly the disadvantages of the scheme proposed be properly assessed.

Dr. **E. S. Grumell** (Chairman of the Fuel Efficiency Committee, Ministry of Fuel and Power) said the Paper was a very valuable one, because the subject of coal preparation was one which required careful consideration and the Paper contained a lot of information and suggestions. He must disagree with one or two statements, particularly that where Dr. Lessing said that the future development of the coal industry must be in the direction of preparing its products in a form to suit the consumers' needs, instead of compelling the consumer to make the best of what happened to be supplied to him. In the first place, that was not altogether a fair statement, because before the war the coal industry had greatly increased the preparation of clean and sized coals, generally at the request of the consumer, with the result that they now had such a multiplicity of sizes that they had to set up a committee to get them simplified, and over and above that they had developed many combustion appliances which were much too highly selective. There was another way of looking at this problem, a way which, in view of the rapidly increasing cost of coal, might be very important. They should seriously consider asking the industry to produce coal as cheaply as possible, and use their technical ability to design appliances to use efficiently what the coal industry could produce most economically. Perhaps that was an opposite extreme. That did not of course exclude preparation of clean coal—he preferred that title to the new title of separation into constituents. It was certainly difficult to understand why, with the evidence of its technical advantages, this development had been so long delayed, and it was a subject which wanted careful examination round a table by those consuming industries which were most particularly interested in the subject and the coal industry itself.

With regard to the de-dusting of coal, if there were to be any changes after the war in preparation and sizing the problem of the removal and treatment of fines would be of major importance, and he was glad to see that the Author did not anticipate any practical difficulties in dust removal, and he hoped other people would agree with that view.

Mr. **L. F. Jeffrey** (West Midlands Joint Electricity Authority) said it seemed that in the future there would be a change-over from domestic consumption of coal and probably a higher use of gas and electricity, and therefore the electrical people, in common with the gas people, would be drawing a higher percentage of those coals which have been devoted to domestic consumption, and further treatment would be

required. On the other hand, for such purposes as locomotives, larger coal would be required. Considering the main question of the use of coal for large electricity generating stations, one was faced with the problem of using the coal on chain grate stokers or pulverizing it. In the case of pulverized fuel there was undoubtedly more efficient use of the coal, but one was faced with the problem of collecting the fine dust and disposing of it. The final problem was, of course, an economic one depending on the facilities available for disposing of the dust.

Mr. **A. E. Lawrie** (Sheffield), in a communication presented to the meeting by Mr. Needham, suggested that the future conditions inside the coal industry were in the hands of the chemist, not the miner, and the proper evaluation of the components of coal would eventually provide a more rational basis of economics and benefits. Dr. Lessing had made only short reference to the actual preparation of coal and more to the utilization, which gave little opportunity for comment on that important aspect. However, there were one or two points that might be considered; for example, Dr. Lessing indicated that the separation was somewhat as follows; Bright coal below 1.35 sp.gr.; dull coal, &c., between 1.35 and 1.6 sp. gr. His own experience showed that the first cut must be made considerably below 1.35, and that the full utilization of the different products might demand two different qualities of middlings of well-defined character between the first cut and about 1.8 sp. gr. Even with a very low gravity cut producing coal of an ash content of the order of 1–2%, heavier fractions could be separated apparently of suitable character for steam raising both as to free burning properties and ash content. Dr. Lessing had stressed the advantages of de-dusting, and although de-dusting was not, of course, an essential to the rational preparation of coal, it might well be that the utilization of the various coal products would produce more incentive for its application, which at the moment was principally connected with the coking industry.

Mr. **Gardner** (Tottenham and District Gas Company) said he would like to add his support to what Dr. Lessing had said about the tests that were carried out at Tottenham some ten or twelve years ago. The whole thing consisted essentially of a comparison of the results, both as regards gas production and the products, from Yorkshire slack at one end and also from the same Yorkshire slack after cleaning. They treated about a thousand tons in the test, and the results which Dr. Lessing had given were those for which he was largely responsible. If he could assist in elucidating any of the information that had been given he would be very pleased to do so. It should be pointed out that the water gas tests were not really comparable because, although they carbonized a thousand tons of coal, the quantity of coke used in the water gas tests was affected by the fact that it had to be transported from one works to another for the test. They were not able to get a satisfactory sizing for each class of coke early enough in the test to get a sufficiently long run for the results to be properly comparable. There was one other point concerning the gas made from the coal on that occasion. There was no record made of the gas produced and therefore comparisons on that score were not made, the reason being that the retort house took 350 tons per day, and it was considered impossible to put the whole of the retorts on to that particular coal, so that half the retorts were used, with the consequence that the exact amount made could not be determined.

Mr. **Elvet Lewis** welcomed a Paper which suggested tackling coal and making it into a product which was very efficient and more valuable instead of suggesting the manufacture of machinery to burn raw coal more efficiently. He deprecated Dr. Grumell's suggestion that the colliery should be concerned with the producing of raw fuel and then not do anything that concerned the user. The coal industry had suffered very much from that practice in the past, and it would not have found itself in some of its present difficulties if it had taken a greater interest in the preparation of the fuel. There were one or two points that arose from Dr. Lessing's Paper. He imagined that if all coal, or most of it, were prepared in the way he suggested, a certain re-allocation of markets might be necessary for the products of particular mines, since it could be contended that there could be more efficient use for other purposes than those for which they were at present used. He could also anticipate the position arising that if the coal industry was concerned in producing a very efficient product there would be a demand for the best types of coal and the best products for each purpose, and a danger that might ensue was one of mining the better seams or those seams that would give those products most easily and leaving other seams unworked; that was a definite danger in the coal industry.

Dr. **E. W. Smith**, proposing a vote of thanks to Dr. Lessing, remarked that to say that the Gas Industry or any other industry must fit itself always to the raw materials as it found them was contrary to all practice in any other industry. While every endeavour was made within economic reason to produce results which were as near as possible reproducible from day to day, it was not practicable to ignore any question of up-grading.

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GAS PRODUCTS PRICES—STOCKS AND SHARES

The London Market Oct. 25.

All Coal Tar Products are in good demand, and Pitch in the London area remains about 45s.

An Order entitled The Control of Toluene (No. 3) Order, 1943 (S. R. & O. 1943, No. 976), came into force on July 20, and introduced certain changes in the prices for different grades of Toluene.

There are no changes to report in the prices of Coal Tar Products.

The Provinces Oct. 25.

The average prices of gas-works products during the week were: Pitch and Crude Tar,* Toluole, naked, North, 90's, 1s. 11d., pure, 2s. 1d. (controlled by the Control of Toluene No. 3 Order, dated July 14, 1943, operative from July 20, 1943). Naphtha and Xylole controlled by the Coal Tar Naphtha and Xylole Order, 1943, dated May 31 (S. R. & O., 1943, No. 768), operative from June 1. Carbolic acid, 60's, naphthalene, and anthracene controlled by the Coal Tar Products Prices Order S. R. & O. 2509, dated Dec. 7, 1942, and operative from Jan. 1, 1943. Filtered heavy oil (min. gr. 1,080), 7½d. to 8d. Creosote oil has been generally controlled as to direction and price for some time past. Current value—fuel grades 5d. to 5½d.; timber preservation and other purposes 4¾d. to 6d.

* In regard to pitch and crude tar prices we would ask readers to refer to the editorial note on p. 396 of the "JOURNAL" for Sept. 10, 1941.

Tar Products in Scotland Oct. 23.

Deliveries continue on a large scale. Refined tar controlled. Value is 4½d. per gallon *ex* Works, naked. Creosote oil: Specification oil, 6½d. to 7d.; low gravity, 7¼d. to 7½d.; neutral oil, 6d. to 6½d.; hydrogenation oil, 5⅞d. per gallon; all *ex* Works in bulk. Refined cresylic acid is in good call at 3s. 6d. to 4s. 6d. per gallon *ex* Works, naked, according to quality. Crude naphtha, 6½d. to 7d. per gallon. Solvent naphtha: Basic prices delivered in bulk, 90/160 grade, 2s. 8d., and 90/190 Heavy naphtha, Unrectified, 1s. 10½d.; Rectified, 2s. 3d. per gallon. Pyridine: 90/160 grade, 13s., and 90/140 grade, 15s. per gallon.

Apart from some little support for home railway stocks, markets were dull and inactive throughout the whole of last week. Although the war news is good, investors are inclined to await developments at the Moscow Conference.

Business in the Gas Market was also on a smaller scale last week, but prices with few exceptions continued well maintained.

The supplies of ordinary stocks on offer are still very limited and practically confined to Gas Light units and United Kingdom £1 shares, although there is a parcel of £5,000 Montevideo stock available at 96 yielding 8¼% on a free of tax dividend of 4%. Preference stocks are also short, the principal offers being £22,000 Gas Light 3¾ (1970) at 96 yielding 4% after allowing for redemption, and a small parcel of £402 South Suburban 3¾ (1967) at 94 giving a return of £4 3s.%. On the other hand, there is plenty of debenture stock on offer yielding from £3 16s.% to about £4 7s. 6d.%.

The following price changes took place during the week:

OFFICIAL LIST		
Barnet	155—160	+2
Bombay	24/—26/—	+-/6d.
Commercial 3 p.c. Deb.	67—72	+1
East Surrey "B"	88—93	+1
Gas Light 3 p.c. Deb.	84—87	−½
Imperial Continental Ord.	93—96	−2
South-Eastern Gas Corporation Ord.	21/3—22/3	+-/3d.
South Metropolitan Ord.	88—91	−1
SUPPLEMENTARY LIST		
Brighton & Hove 5 p.c. Deb.	117—122	−3
Cheltenham 4 p.c. Deb.	95—100	−7
Croydon 4 p.c. Deb.	100—105	−1
PROVINCIAL EXCHANGES		
Chester 4 p.c. Cum. Pref.	80—82	+2
Ditto 4 p.c. Non-Cum. Pref.	80—82	+2

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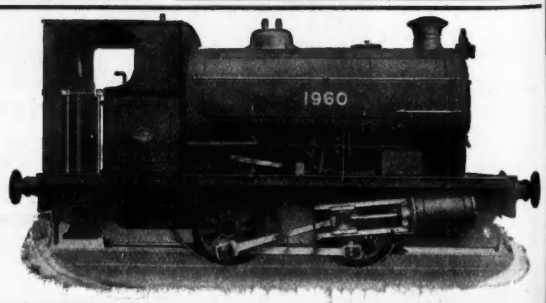
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